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The Illustrated War News

The Commander of an English Submarine Boat taking an observation through the periscope, which enables him to direct the movements of his craft

LIFE IN A SUBMARINE—[See page 356]

The Inertia of Energy*

As Related to the Evolution of Matter

By Prof. Louis Rougier, Fellow of the Algiers Lyceum

UNTIL the last few years modern physics was based upon a fundamental dualism, that of matter and of energy. Between the properties of these two agents of all natural phenomena there was believed to be a radical antithesis—matter alone being endowed with mass, with weight in proportion, and with structure, and energy possessing neither inertia, weight, nor structure. Both are alike indestructible, upon which fact are based two distinct principles: the principle of the conservation of the mass and that of the conservation of energy.

The series of discoveries made during the last 20 years concur, if not in the rejection of this dualism, at least in the ruin of this antithesis; they oblige us to so assimilate matter and energy as to endow them with common properties. But the two terms of an antithesis may be assimilated in two very different fashions. We may reconcile the first term with the second and maintain the dematerialization of matter; or we may reconcile the second term with the first and maintain the materilization of energy.

Dr. Gustave Le Bon, in "The Evolution of Matter," has essayed the first reduction, by showing that matter disintegrates into electrons, which themselves are dissipated in the form of radiation in the ether; Einstein has essayed the second, by showing that the principle of relativity tends towards the endowment of energy with inertia. There result inevitable discordances between these two methods of procedure, but also remarkable concordances which it is interesting to set forth.

For convenience in our exposition of the subject let us enunciate the postulates of the dualist doctrine in the following manner, the last two postulates being the consequence of the first:

1. The presence of energy in matter does not increase its inertia.

2. The presence of kinetic energy in particular, *i. e.*, the state of movement of a body, does not increase its mass.

3. The absorption or emission of energy by radiation neither increases nor diminishes the mass of a body.

It results from these three propositions that the mass of a body is invariable, and that energy is lacking in inertia.

Let us bear in mind that mass can be defined in at least two distinct manners. It may be defined as the coefficient of inertia, by the quotient of the force and of the acceleration $M = \frac{F}{\gamma}$; it may be defined as the coefficient of capacity of movement, called maupertuisian mass, as the quotient of the quantity of movement of a body $g = mv$ by the speed, *i. e.*, $M = \frac{g}{v}$. Later we shall have to recall this second definition of mass, which classic mechanics regards as equivalent to the first.

I

J. J. Thomson overthrew, in 1881, the first postulate of the dualist theory, by showing that *an electrified body, by reason of the electrostatic energy of its charge, possesses a supplementary inertia of electromagnetic origin.*

This results from the self-induction of currents of conduction, from the existence of currents of convection, and from the identity of these two kinds of currents with respect to the magnetic actions which they generate.

The self-induction of currents is a true electrical inertia which opposes itself to any change of intensity of currents, just as material inertia opposes itself to any change of speed of movable objects. Just as it is necessary to expend a certain amount of effort to put a body in motion, similarly it is necessary to expend a certain amount of work to establish a current; and just as a movable object when set in motion tends to preserve its rate of speed, in the same way a current once established tends to preserve its intensity.

The existence of currents of convection, predicted by Maxwell in virtue of the law which connects the variation, in time and in space, of the electric field and of the magnetic field, has been verified experimentally by Rowland. It consists in the fact that a charged particle in motion comports itself like an element of current, *i. e.*, it generates a magnetic field in which the circular lines of force are superposed on the radial lines of force of the electric field. A charged particle in motion, by reason of the current of convection which it generates, must possess a self-induction, *i. e.*, an excess inertia, of electro magnetic origin, which will be added to its inertia proper and will increase its mass. Max Abraham and then Lorentz demonstrated, the first in virtue of the law of Maxwell, the second in virtue of the principle of relativity, that this supplementary inertia must increase with the speed and become infinite for the limited speed of light.

The fortunate parallelism which occurred at this period between the progress of theoretical and of experimental physics revealed in the cathodic emanation proceeding from Crookes tubes, and in the β rays proceeding from the atomic disintegration of radio-active bodies, electrified particles moving at speeds varying from 30,000 to 290,000 kilometers per second. An experimental verification of the laws of Max Abraham and of Lorentz became possible, which, undertaken by Kaufman and then by Bucherer revealed two things: the particles in question are elementary charges, without material support, of atoms of resinous electricity whose inertia is of electromagnetic origin solely; their inertia varies with the speed conformably to the law predicted by Lorentz. The following consequences ensue:

1. One form at least of energy, electric energy, is inert.

2. The presence of a certain quantity of electric energy in a body increases its mass;

3. This supplementary mass, of electromagnetic origin, varies in function of the speed.

If we accept the electronic theory of matter, according to which molecular structures are architectural edifices of electrons, we are led to the following generalizations, which are imposed as we see by the principle of relativity:

1. The mass of material bodies is of electromagnetic origin solely.

2. The mass of bodies varies in function of the speed.

II

It is not entirely this sort of consideration which has led Einstein to the idea of the inertia of energy. It is the principle of relativity, joined to the principle of the conservation of the quantity of movement in a closed system, or, what amounts to the same thing, the equality of action and reaction.

The principle of relativity springs from the checking of all attempts to demonstrate the absolute movement of a system by experiments made in the interior of that system. Classic mechanics has already admitted that mechanical phenomena, in a system animated by a uniform rectilinear movement, occur precisely as if the system were in repose.

An observer enclosed in the bullet of Jules Verne would be able to perceive the accelerations and rotations undergone by the bullet; but he could in no way become aware, by mechanical experiments, of his movement of uniform translation. This ceases to be true if he resorts to optical or electrical experiments. The electromagnetic theory of light assumes the intervention of a medium in repose, the ether, which transmits the transverse waves of light with a definite velocity, as air transmits waves of sound. In the case of a sonorous source the relative movement of the source with respect to the air can be measured without thereby revealing the absolute movement of the source with respect to the ether, since the air is entrained with the body. This ceases to be the case with the ether. The latter, if it exists, is immobile by virtue of the experiment of Fizeau so truly so that one might hope, by means of optical experiments in the interior of a system, to detect the absolute movement of a luminous source, connected with the system, with respect to the ether.

Experiments have been very numerous in this direction, in particular those of Michelson and Morley. They have all led to the same negative result: *given different groups of observers O and O¹ some of which have a uniform movement of translation with respect to the others, the physical laws are exactly the same for these different groups of observers.*

The preceding principle, called the principle of relativity, involves numerous consequences which revolutionize the classic ideas of time, space, causation and solid bodies. One of the most astonishing is the contraction of all bodies in the direction of their translation, in the ratio $\sqrt{1 - \frac{v^2}{V^2}}$, v designating their velocity, and V the velocity of light in vacuo.

The same principle requires, as Lorentz has demonstrated, not only that all bodies in movement, electrons or material systems, shall undergo this deformation, but that their mass shall vary in function of speed as if it were of electromagnetic origin solely, *i. e.*, as if the electronic theory were true, in which case the preceding generalizations would be justified.

Of those consequences we will retain but a single expression: *absolute movement is a physical absurdity.*

The inertia of energy results, therefore, from the necessity of reconciling the pressure of radiation with the principle of relativity.

Maxwell, starting from the electromagnetic theory of light, and Bartoli, starting with the principles of thermodynamics, predicted theoretically, and Lebedef verified experimentally that all radiation exerts a pressure towards the rear upon the source of emission, and an impulsion forward upon the obstacle which absorbs it. This is what is termed the pressure of radiation.

The existence of this pressure leads us to believe in the inertia of energy, if we desire to preserve the principle of the conservation of the quantity of movement in a closed system, or the principle of action and reaction, of which it is a simple corollary, at the same time as the principle of relativity.

The principle of the equality of action and reaction declares that if a body *A* acts upon another body *B*, the body *B* reacts upon the body *A*, and that these two actions are constantly equal and opposite. It results from this, in the case of a closed system, that the total quantity of movement is conserved. If a body provokes, by an interior action, the appearance of a certain quantity of movement, counted positively, in acting on another body, it will undergo a repulsion on the part of the latter, and will consequently lose a quantity of movement which, because of the equality of action and reaction, will be equal to the first and in the contrary direction, so as to compensate it. The center of gravity of the system will remain immobile.

Let us consider, for example, a material system whose movements are due to interior action only, such as a firearm and its projectile.

When the shot is fired the gun undergoes a recoil, *i. e.*, it takes a certain quantity of movement which counted negatively represents a loss; the projectile is projected forward and acquires a quantity of movement which, counted positively, is equal to that lost by the gun.

There is a conservation at all times of the total quantity of movement of the system, and, consequently, fixity of its center of gravity. The conservation of the quantity of movement is only a natural consequence of the instantaneous equality of action and reaction: the gun recoils because, while acting upon the projectile the latter reacts equally upon it.

Let us consider now a material source which radiates dis-symmetrically, in a single direction, like a lamp with a reflector or a Hertzian exciter in the center of a parabolic mirror. At the moment of emission the source recoils because of the pressure of radiation; there is a loss of a quantity of movement. If the radiation encounters an obstacle which absorbs it, it communicates to it an impulse, *i. e.*, a quantity of movement equal to that lost at the departure by the source. The action experienced by the obstacle will be equal therefore to the reaction undergone by the source.

Does this imply that the principle of the conservation of the quantity of movement, or of action and reaction, will be respected? Assuredly not, for this is not the case at first at each instant. There elapses a certain period of propagation between the time when the radiation is emitted and that when it is absorbed, during which the quantity of movement lost by the source and the reaction which is the cause of it remain without compensation. This compensation will never take place if the radiation is propagated infinitely without encountering matter which absorbs it. In such case there will be a definite loss of a quantity of movement, and the center of gravity of the system formed by the material source and the radiation will acquire an absolute movement, which is contrary to the principle of relativity.

If we desire to preserve this principle and likewise that of the conservation of the quantity of movement, it is necessary to assimilate the source—radiation system to the material system of the gun and its projectile; we must treat the radiation as a material projectile, *i. e.*, consider that it represents a certain quantity of movement equal to that lost by the source, so that the action experienced by the source shall be the natural effect of the action exerted upon it. In this case only, the center of gravity of the system will remain fixed, and the principle of relativity will be respected.

*This note has been specially prepared as an appendix to *The Evolution of Matter* by Dr. Gustave Le Bon.

Translated from *Revue Scientifique* for the SCIENTIFIC AMERICAN SUPPLEMENT.

But quantity of movement implies, by definition, that a mass is in motion, by virtue of the vectorial relation g.=mv. The projectile in its movement carries away a part of the initial mass of the loaded fire-arm, which finds itself diminished by an equal amount. It is for this reason that there is an instantaneous equality of action and reaction, conservation of the quantity of movement, and immobility of the center of gravity of the system. If, therefore, a radiation is a vehicle of quantity of movement it must necessarily be that it carries away with it a part of the initial mass of the radiant material source.

To measure this mass it suffices to estimate the quantity of movment which a radiation represents. It should be equal to "the pressure of radiation" exerted upon the source which emits it. The value of this pressure $=\frac{E}{V}$, in which E represents the density of the radiating energy emitted in the unit of time, and V the velocity of the light. The quantity of movement, therefore, has for its value:

$$(1) \quad g=\frac{E}{V}.$$

The Maupertuisian mass being equal to $M=\frac{g}{V}$, we get for this mass, by replacing g by its value in the preceding formula:

$$(2) \quad m=\frac{E}{V^2},$$

the mass of radiant energy is equal to the quotient of the energy by the square of the velocity of light. The radiation, like all resinous electricity, possesses an electro magnetic inertia.

Since all forms of energy can be converted into radiation we can generalize the preceding result in the following manner:

Every form of energy, whatever it may be, has a coefficient of inertia, a mass equal to $\frac{E}{V^2}$. If a body radiates energy the radiation emitted carries away with it a part of its initial mass, or $\frac{\Delta E}{V^2}$, and when an obstacle absorbs this radiation, its mass is increased by the entire Maupertuisian mass of the absorbed radiation $\frac{\Delta E}{V^2}$. This leads us therefore, to the following proposition:

The mass of a body is not invariable; it diminishes or increases according to whether the body emits or absorbs energy, in the ratio $\Delta m=\frac{\Delta E}{V^2}$. The last postulate of the dualist theory is therefore, proved to be faulty.

The mass of bodies being no longer a constant quantity, *the principle of the conservation of the mass of material bodies ceases to be true of itself.*

There remains only the principle of the conservation of energy. In an isolated system, whose different parts exchange energy between themselves, the individual masses of the bodies present are not conserved; that which is conserved is the total inertia of the system, and consequently its energy. According to the relation (2), if we take the velocity of light as the fundamental unit, we see, in effect, that *the mass of a body is equal to its total energy*, or again that *the mass of a body measures its internal energy.*

III

A first consequence of the inertia of energy is the possibility of calculating the internal energy of bodies. For this purpose it suffices to apply the formula $E=mV^2$, which we can immediately derive from (2). We find that a gram of matter, taken at rest and at the temperature of absolute zero, corresponds to the presence of an internal energy equal to 9×10^{-20} ergs, *i. e.*, equivalent to the heat furnished by the combustion of 3×10^9 grams, or three million kilograms of coal. It is interesting to compare this figure with that found by Dr. Gustave Le Bon, starting with the kinetic hypotheses on the constitution of the atom. This author estimates the energy condensed in a gram of matter at 2,830,000 kilograms of coal.

This colossal internal energy can only be an intra-atomic energy. In effect, at the absolute zero, the molecules are as if ankylosed by freezing, and, moreover, the physical molecular forces and the chemical atomic forces set in operation only a quantity of energy which is very small compared to this colossal reserve of latent energy, as is easily accounted for.

1. *Variation of mass with temperature.*—The same portion of matter, taken at two different degrees, can pass from one to the other by emission or absorption of radiant heat. We can calculate the variation of mass which results therefrom by dividing by V^2 the quantity of heat exchanged with the exterior. To comprehend the degree of size of the predicted effect let us consider water, whose calorific capacity is particularly high. A mass of water having at 0° an inertia equal to one gram will have a greater inertia at 100°. The difference will be obtained by dividing the absorbed heat, 100 calories gram-degree or 4.17×10^9 ergs, by V^2, equal in the same system of units to 9×10^{20}, which gives about 5×10^{-12}, that is to say, a practically insensible variation.

This example proves, nevertheless, that we can no longer confound the idea of mass with that of quantity of matter, as did Newton. Two masses of water of equal inertia, taken one at 100 and the other at 0°, do not contain the same quantity of matter, the same number of molecules, since they cease to be equal when we bring them to the same temperature.

2. *Variation of mass in chemical reactions.*—Chemical reactions being all either exothermic or endothermic, the sum of the masses of the combined elements does not remain constant, by virtue of the relation $\Delta E=V^2 \Delta m$.

Let us take, for example, the formation of water from its elements in the gaseous state. The combination of two grams of hydrogen and 16 grams of oxygen liberates 69,000 calories gram-degree, equivalent to about 3×10^{12} ergs. Therefore we should not obtain 18 grams as the result of the combination, for the heat disengaged in the form of radiation involves a loss of mass equal to $\frac{1}{3} \times 10^8$ grams, or a difference of five billionths between the mass of the exploding gas and that of the water which it can form at the same temperature.

3. *Variation of mass in radio-active transformations.*—The same thing will hold in radio-active transformations. The initial mass of one of these bodies and the total mass of its products of disintegration at the end of a certain time, will not be equivalent, the transformation being accompanied by radiation. We know that a gram of metallic radium sets free 130 calories per hour. At the same time that it is being transformed into radium D and into helium, through the successive forms of emanation, of radium A, B, C. Taking into account that the average life of an atom of radium is 2,600 years, we can calculate that the total transformation of one gram of radium into helium and into radium D will liberate energy equal to 1.1×10^{17} ergs. This emission of energy will correspond to a difference between the primitive mass of the radium and the total mass of the radium D and the helium equal per gram to $\Delta m=\frac{1.1 \times 10^{17}}{9 \times 10^{20}}=1.2 \times 10^{-4}$. The disintegration of radium into helium and radium D represents only one stage of the transformations which start with uranium to end in helium and in lead. The complete disintegration of a given quantity of uranium into helium and lead would represent a loss of mass greater than one ten thousandth of that of the primitive uranium.

The fraction of the mass which is thus transformed into radiant energy is of much greater size than is the case in chemical reactions. It is to be presumed that it proceeds from the latent energy of the uranium, that is, from its intra-atomic energy. If we could succeed in establishing exactly, up to sizes of the degree of 10^{-4}, the balance of the masses in the case of radio-active transformations, it would be possible to verify the identity of the mass and of the energy.

To resume, energy is inert, and the mass of a body is equal to its internal energy, which it enables us to measure. This internal energy represents, at the absolute zero, a colossal accumulation of intro-atomic energy. According to whether a body acquires energy or gives it up, its mass increases or diminishes. It is greater for the same body when in motion than when at rest, when hot than when cold, when electrified than when discharged; it varies in chemical reactions, and even more perceptibly in radio-active transformations.

The mass of a body can transform itself into radiant energy and vice versa, so that mass and energy become two equivalent magnitudes convertible one into the other, like mechanical labor and heat. The principle of the conservation of the mass is included in the more general and only rigorous principle of the conservation of energy. It is very impressive to compare these conclusions with those which Dr. Gustave Le Bon has derived from a very different order of considerations. Their concordance assumes the significance of a guarantee of objectivity.

The Formation of Diamonds

For some years nothing seems to have been written on artificial diamonds, and the practically negative results of the new experiments of Professor Ruff, extending over three years, will hardly induce others to take up this study. The systematic research of Ruff (*Zeitschrift für Anorganische Chemie*, pages 73 to 105, May 15, 1917) was undertaken with the object of testing all the reactions likely to lead to a deposition of carbon, and he tried in particular, also, whether small real diamonds would grow under his experimental conditions. To bar the possibility of mistakes in view of the fact that any resulting growth would probably be minute, he purified these diamonds first with hydrofluoric, nitric and sulphuric acids, potassium nitrate, and, finally, with chlorine at 1,000 deg. C. He confirmed the statement of previous experimenters that small crystals of carborundum and alumina, even of quartz, had apparently been mistaken for diamonds, and his own artificial crystals, which fluoresced like diamonds in ultraviolet light and under α-radiation, were too small to admit of any conclusive analysis. In the first series of experiments he submitted gases (coal gas, acetylene, carbon tetrachloride, carbon monoxide, methane, etc.), alone or mixed with vapors (iodoform, benzene, carbon disulphide, etc.), to temperatures ranging from 200 deg. C. up to 3,500 deg. for 14 days, without obtaining more than an amorphous or graphite growth, except in one case. The carbon electrode arc of 5,000 volts alternating and 0.5 ampere, burning in liquid air for a very short time, yielded some very small crystals; arcs burning in flowing water and singing arcs did not give any distinct result, though the hard mass forming at sharp points left no residue when burnt. Experiments with liquids, heated up to 30 days, of paraffin, wax, graphite acid, pitch, diphenylanine, etc., to which sometimes various metals (mercury, silver, silicon, aluminium, sodium, etc.) were added, were resultless. Quenching fused metals saturated with carbon at 1,350 deg. C. (iron alone or alloyed with high percentages of silicon, titanium, vanadium, tungsten; also cobalt, nickel or manganese) yileded very small diamonds such as Moissan obtained; but an alloy of low melting-point (850 deg. C.), consisting of 100 parts by weight of iron, 100 parts of antimony, and 60 parts to 75 parts of manganese, yielded nothing, not even when a small diamond was embedded in the alloy, which was heated in a carbon arc. Fused silicates, etc., were no good either as solvents for carbon; this is particularly interesting, because Ruff especially tried silicates of the composition of the blue ground of Kimberley, in which diamonds occur. Nor did Ruff obtain any diamond-like crystals by electrolyzing at 2.200 deg. fused calcium carbide, with which method Boismenu claimed to have been successful a few years ago. Finally, Ruff made experiments with a steel bomb, similar to that which Johnston and Adams had used in 1911 at Washington, at hydraulic pressures of 3,000 atmospheres, to heat liquids (oils, etc.) and gases (CO) for days and to produce a carbon arc in gas or in water. A carbon rod of 1.5 mm. diameter, heated in water by currents of 35 ampered at 80 volts, burned through in 5 seconds, but the drop of fused carbon merely solidified to a hard graphite.—*Engineering.*

Pacifying the Jack Rabbit

For the past eight months we have succeeded in keeping the western jack rabbit on exhibition. All previous attempts with this excessively nervous animal have been failures. New arrivals frantically try to escape, and become so frenzied they run blindly against the cage-work and suffer fatal injuries. A specimen which arrived last summer was given a big box in which to hide, and gradually we made friends with him by enticing him out with food. When he began investigating his yard without symptoms of panic, another specimen was ordered from the West. The second specimen at once gathered confidence from the calm demeanor of the first, and the pair now live happily. Visitors are at once interested in these animals, owing to the rabbits' grotesque ears, which are of enormous size, and according to the mood of the animal are directed at eccentric angles. This successful experiment of maintaining the species has led us to consider plans for a colony of jack rabbits. The idea is to exhibit them in a roomy enclosure like that of the prairie dogs.

—*New York Zoological Society Bulletin.*

Fluorescent Bacteria

The existence of fluorescent bacteria has been recorded, though the coloring matter produced by them is insoluble in ether. Further, E. Rostrup has observed that *Agaricus* (*Pleurotus*) *scrotinus*, Schrad., imparts a peculiar fluorescence to spirits of wine, and A. Ling found that a Torula occurring in ale gave to it a greenish fluorescence. Now Prof. A. Klocker (*Comptes rendus des travaux du Laboratoire de Carlsberg*, vol. ii., part 6) describes the production of a faint greenish fluorescence when *Aspergillus glaucus* is grown in a medium containing sugar, and the isolation of the coloring principle. When the medium (*e.g.* beer wort) in which *A. galucus* has been grown is shaken with ether, the latter acquires a faint yellowish color, and in thick layers a blue fluorescence. If the ethereal solution is shaken with ammonia this exhibits a very marked green fluorescence, whilst if soda be used the fluorescence is reddish-brown. On evaporation the ethereal solution leaves a yellow residue having the properties described.

The Illustrated War News

The engine room of a submarine, showing the crowded machinery, and the space where the crew have to do their work

The Illustrated War News

The bow compartment of a submarine, containing two torpedo tubes and their discharging mechanism. The torpedoes are in the tubes ready to be sent on their way

Life in a Submarine

WHILE there are hosts of men not only willing, but eager to fly in aeroplanes and fight in tanks, notwithstanding the great personal discomforts of both and the obvious hazards, few are found who have any great desire to serve in a submarine. This may be accounted for by the difference in the nature of the work to be done, which in the case of the under-sea craft is of a furtive and stealthy character as contrasted with the dash and excitement of active combat that characterizes almost every other phase of warfare. Moreover, the dangers, which are serious and constant, must be combatted night and day, often for weeks at a time, instead of for a few hours at most, and consequently the strain on the nervous system is so severe, both physical and mental, that even the strongest men find it difficult to withstand the effects particularly when the limited quarters in which both men and officers are compelled to live are considered.

The illustration on the first page of this issue shows the officer in command of an English boat, watching his surroundings above through a periscope, and it will be seen that his accommodations are neither roomy nor particularly convenient for the important duties for which he is responsible. Another view, on this page, shows the engine room, or what passes for that portion of the craft, and it will be appreciated with what difficulties the care and operation of the complicated and delicate machinery, on which a submarine depends for its existence, is surrounded. In the bow portion of the vessel the crowding of apparatus is not so apparent as in every other part of the boat, because here it is necessary to provide room for handling the big torpedoes and inserting them into the discharging tubes; but this adds but little to the comfort of the crew, who must depend for their breath of fresh air on a narrow strip of deck, which is often awash under the best conditions, and which is not available at all in bad weather. While men of considerable physical courage are necessary for the operation of the under-sea boat the character of the work to be performed, and the blind way in which it is accomplished, cannot appeal to the real fighting man, and the constantly present perils and uncertainties are nerve racking to even the most apathetic and calloused natures.

The Stupendous Smallness of Our Earth

By Charles Nevers Holmes

MAN cannot realize, he cannot calculate how small, how utterly insignificant is his own planet compared with the totality of the universe. Indeed, he scarcely realizes how small is his world compared with only the volume of ether amid which the system of the sun is swiftly moving. To state that his earth is like a ship on the Atlantic ocean, in comparison with the universe, is absurdly inadequate, and it may be that his planet is like a speck of dust floating amid the ocean of air by which he is surrounded. Now, a speck of dust is almost a microscopic particle and, since the atmosphere extends upwards for two or three hundred miles and the planet which it covers has a surface area of about 197,000,000 square miles, man should be willing to admit, although not at all comprehending how vast the universe really is, that the earth upon which he is born and dies, is a body of the importance of a *cipher* compared with the stupendous creation around it.

But to man his planet home looks large enough, because he is so tiny himself with respect to it. "Is not *my* world," he may exclaim, "about 25,000 miles in circumference and, therefore, does it not contain approximately 260,000,000,000 cubic miles?" A mountain five miles in height seems very high to a human being only a little over five feet in height; but, were that human being half-a-million miles in height, he would not notice the mountain and the earth would appear like a very small ball indeed. Because man's body is from his standpoint of rather respectable size, his planet home looks very huge, and since he has devised a system of measures commensurate with his bodily requirements, a world possessing a circumference of about 25,000 miles seems to him pretty large. Perhaps one of the chief reasons why the earth appears so big to most of its inhabitants is that these inhabitants, even in this twentieth century, crawl so slowly upon and around it. Certainly, a "journey around the world" is somewhat of an undertaking to all of the dwellers upon its surface.

Man is earth-chained and earth-educated—usually almost as narrow-minded as the universe is broad. Not that there have been no great men upon this earth, but even the greatest of them have naturally been influenced by their terrestrial surroundings and terrestrial education. To most men their world represents the chief reality of life, the stars and universe outside the world being rather unreal and uninteresting. A square foot of land is something that man can touch, and for one glance that he casts upwards there are a hundred or a thousand glances that he casts downward. As a result of earthly associations man is, with respect to his mind, almost wholly terrestrial. Nearly everything is computed in terms of this world, and the importance of the world is enormously exaggerated by man. Therefore, the real volume or size of this earth has also been enormously exaggerated. It is, accordingly, an excellent idea to "get down to facts" occasionally, and compare the stupendous smallness of this planet with the stupendous vastness of the universe.

Our bright and silvery moon is so comparatively near us that, apart from her beauty and astronomical interest, she is hardly worth considering. Now, this moon's average distance from the earth is about 239,000 miles. The earth's diameter approximates 7,918 miles, so that about thirty earths in a line would reach from the terrestrial to the lunar surface. This does not make our earth seem very small, but wait—in order to bridge the ether-gulf between our world and the sun approximately 11,700 earths would be required, that is, when the sun is at his mean distance from our world (92,900,000 miles). And let us consider the size of the sun. How often we have beheld him shining so brightly in the heavens—apparently only as large as the white, beautiful moon. One who is inexperienced in astronomical science might "guess" that King Sol, is 10,000 times as big as the world Well, such a guess would be a very poor one indeed. The sun is not 10,000 or a 100,000 times as large as our earth, but about one million, three hundred thousand times as large! And our own sun is not a very big star amid the other stars, for there are undoubtedly many suns in the universe thousands of times bigger than he. Compared with such huge suns, the smallness of our earth begins to seem somewhat stupendous.

Our sun is, comparatively speaking, very, very near to us. As is well known, the outermost planet of his system (as astronomical science informs us at present) is Neptune. Well, Neptune approximates a mean distance from us of 2,700,000,000 miles. That is, supposing it to be just 25,000 miles around our earth, we should have to travel more than a hundred thousand times "around the world" to go as far as from this planet to the planet Neptune. And the planet Neptune is scarcely at the threshold of the universe!

Our own sun shines upon us by day, and multi-myriads of stars shine upon us by night. As has been stated, our own sun is at an average distance of *only* 92,900,000 miles, whereas the sun called *Alpha Centuri* which is the next nearest sun to our earth, so far as is now known, approximates a remoteness of 26,000,000,000,000! Not that 26 trillions of miles are anything remarkable, astronomically, but it is somewhat of a "jump" from the 93 million miles to our own sun. In other words, these 26 trillions of miles to *Alpha Centuri* would require, very approximately, 3,300,000,000 earths, the size of our own earth, extending in a line, to reach from our world to this nearest known sun of night!

And, of course, this nearest known sun of night is only on the surface, astronomically. Now, it takes light about eight minutes to reach us after leaving our sun and it takes about four and one-third years for light-rays to reach us after leaving *Alpha Centuri*. There are stars whose remoteness is so enormous that their rays do not arrive here until 500 or 1,000 years from the time they left the fiery surfaces of their suns. That is, their light which we see tonight started from those very remote bodies back in the tenth century or possibly long before that time. At the rate light travels (186,330 miles per second) it would flash more than seven times around our world in one second. How utterly insignificant our tiny planet really is amidst a universe whose *inner* or local boundaries are perhaps more than 3,000,000,000,000,000 miles distant from us!

Of course, the suns and planets contained within the boundaries of the so-called Milky Way constitute only a part—probably only a very tiny part—of the sum total of Creation. Outside of this inner or local boundary the universe may be illimitable, indeed the probabilities are that Creation is illimitable, rather than finite. To a man whose education is wholly terrestrial the conception of an illimitable universe seems unreal—impossible; but such is the opinion of an individual who thinks in earthly "feet" and "yards" and lives entirely within the influence of some local time-piece. Our earth is very small indeed compared with the extent of its own solar system. It becomes almost a cipher compared with the ether-space contained within the confines of the remote Milky Way; and our world seems far less than a cipher when contrasted with an illimitable universe or even with a universe nearly illimitable.

How stupendously small, then, is our own planet-home!—more like a single atom amid the atmosphere surrounding our world than like a dust-speck in the atmosphere. Were we to divide such a dust-speck into particles too minute to be seen by the most powerful microscope, and then re-divide one of these invisible particles into particles a trillion times as small, one of these final particles *might* occupy more relative space in our atmosphere than the earth occupies amidst its universe. Truly, our world with its circumference of a little less than 25,000 miles is utterly insignificant, and perhaps it is fortunate that we who dwell here cannot appreciate how very small and very insignificant our earth really is.—*Popular Astronomy.*

Wave Detectors for Wireless*

The Oscillation Valve

By Dr. J. A. Fleming, F.R.S.

Electric wave wireless telegraphy and telephony involves the use of some form of appliance called a detector, because it detects and renders evident the very feeble alternating currents or electric oscillations set up in the circuits of the receiving apparatus. These oscillations are created by the electric waves coming from the distant transmitter, which fall upon the aerial collecting wire attached to the receiver, and create rapid alternating currents in it. Hence this aerial wire is like a hearing trumpet and the detector like the ear; or the aerial may be compared to the lens of a telescope which collects the light and the detector to the eye which is sensitive to the light waves.

COHERERS

In the early days of wireless telegraphy the detector used was the coherer, which, in the form given to it by Marconi, consisted of a glass tube having in it two plugs of silver, nearly touching, and between them a minute quantity of nickel and silver filings. When electric oscillations passed through these loose filings they caused the grains to cohere and so increased the electric conductivity of the mass. This change permitted a current from a local battery to flow through a relay, which in turn operated to close the circuit of a second battery, which actuated the signal-recording instrument. The coherer tube then required a tap to be given to it to restore it to a condition of sensitivity for the next impulse. The connections and adjustments of coherer, tapper, relay, and printer required much skill, and were easily upset. Hence before long this form of coherer was abandoned.

Then followed several forms of coherer detector which did not require tapping, but were self-decohering, such as the rotating steel disk in mercury of Lodge and Muirhead, the mercury carbon coherer of Castelli, and the mercury-tantalum coherer of Walter. These appliances had a limited application, and the next really practical advance was the magnetic detector of Marconi based on the power of electric oscillations to vary the form of the cyclical magnetization curve of hard iron. This instrument was used with a telephone, and being simple, easily adjusted and not readily put out of action, it greatly aided in making radiotelegraphy a practical success.

Increasing telegraphic ranges demanded, however, a more sensitive detector, and an entirely new field of discovery was opened up by the writer's invention in 1904 of the thermionic detector, the first form of which was made known in a British patent application, No. 24850 of November 16th, 19104, by J. A. Fleming, and in a paper on "The Conversion of Electric Oscillations into Continuous Currents by Means of a Vacuum Valve," read to the Royal Society of London on February 9th 1905, and published in the *Proceedings* for 1905. This thermionic detector has proved itself to be of enormous utility for detecting electric waves as used in radiotelegraphy or telephony. It depends for its operation on the fact that incandescent bodies in a good vacuum emit electrons, generally negative, though under certain conditions positive ions may also be evolved or produced in the residual gas existing even in a high vacuum.

EDISON'S OBSERVATION

The starting point for the invention was an interesting observation made by Mr. Edison in or before 1884, as follows: If an electric incandescent carbon-filament lamp has a metal plate carried on a wire sealed into the bulb, but not touching the filament, then on rendering the filament incandescent by a direct current it will be found that a galvanometer connected in between the terminal of the metal plate and the positive terminal of the filament will indicate a current; but little or no current will be shown if the galvanometer is connected between the negative terminal of the filament and the metal plate. This fact excited scientific curiosity but no practical application of any kind was made of it by Mr. Edison, nor did he explain it.

It was further investigated in 1885 by the late Sir William Preece, who read a paper on it to the Royal Society, and it was examined at still greater length by the present writer in 1889, 1890 and 1896 in papers read to the Royal Society and to the Physical Society. The writer came to the conclusion that the phenomenon was due to the emission of negatively charged atoms or molecules from the filament. In those days the conception of an electron or particle smaller than an atom had not been reached, and it was not until after Sir Joseph Thomson's epoch-making researches that it was recognized that the particles emitted were not atoms of matter but atoms of electricity 2,000 times smaller.

RECTIFICATION OF CURRENT

In spite of all these investigations there was not the smallest suggestion that such a glow lamp with metal plate sealed into the bulb could be used as a detector of electric waves until 1904. At that date the writer was endeavoring to utilize a mirror galvanometer, as used in submarine telegraphy, to detect wireless signals, but this required that the movement of electricity in the galvanometer circuit should be always in the same direction. The electric oscillations set up in the receiving circuit by the radiotelegraphic waves are, however, alternating currents of very high frequency, and with these both the mirror galvanometer and the telephone are inoperative. Hence it appeared necessary to find some means of rectifying the oscillations or suppressing the movements of electricity in one direction, so that to each train of oscillations set up by the spark at the distant transmitter there might correspond in some part of the receiving circuit a simple unilateral flow or gush of electricity.

After careful experiments the writer arrived at the conclusion that this rectification of the electric oscillations could be achieved by inserting in the oscillatory circuit a vacuum valve consisting of an exhausted glass bulb having a carbon filament sealed into it like a lamp, and also a metal plate carried on a third terminal, the filament being made incandescent by an insulated battery

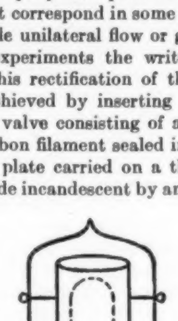


Fig. 1—Fleming oscillating valve

and the oscillatory circuit connected to the metal plate and to one terminal of the filament. Experiment showed that this valve rectified the oscillations, permitting only the movements of electricity in one direction to pass through the vacuum between the hot filament and the cold plate—viz., those which required movement of negative electricity from the filament to the plate.

APPLICATION OF VALVE

It then became possible to use an ordinary galvanometer or telephone receiver to detect feeble electric oscillations provided that a vacuum valve as above described were inserted in series with it. In that system of wireless commonly called the spark system the transmitter sends out groups of electric waves tailing away in amplitude at each spark discharge of the condenser. Hence in the receiving circuits there are trains of intermittent oscillations, and when these are rectified by a vacuum valve there are intermittent gushes of electricity flowing in the same direction. In modern spark systems these sparks or trains are produced at the rate of 500 to 1,000 per second. This unidirectional but interrupted current is exactly that for which the telephone is most sensitive, and hence a vacuum valve placed in series with a telephone and attached to the terminals of the condenser in the receiving circuit of a wireless telegraph plant enables us to hear as a shrill musical sound the rapid series of sparks at the transmitter. When this series is cut up by the sending key into long and short groups in accordance with the signals of the Morse code we have the means of transmitting intelligible words.

This valve receiver depends essentially upon the emission from incandescent bodies of electrons or atoms of negative electricity, and therefore the name thermionic detector is applied to it and its modifications. It was the first thermionic detector to be employed in wireless telegraphy. One great advantage of it is that it cannot be injured or put out of action by atmospheric electric discharges or by electric waves set up by an adjacent transmitter. The actual valve used in practice is like a small incandescent lamp with carbon or tungsten filament, which is rendered incandescent by a 4 or 6 cell battery of small storage cells. The plate takes the form of a small metal cylinder sealed into the bulb, surrounding but not touching the filament.

THE DE FOREST AUDION

The device was adopted in practical wireless telegraphy early in 1905 by Marconi, to whom it had been shown by the writer, and it was used by him with a telephone for receiving wireless messages. It soon attracted the notice of other radiotelegraphists, among others Dr. Lee de Forest in the United States. De Forest had already been experimenting with a Bunsen burner as a possible oscillation detector, but without much success.

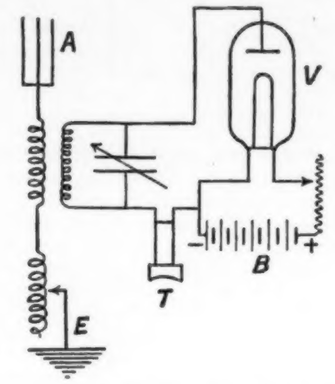


Fig. 2—Oscillating valve as wave detector

A, antenna; *B*, heating battery; *E*, earth plate; *T*, telephone, *V*, valve.

He soon realized the virtues of the Fleming oscillation valve and applied for a number of United States patents for essentially similar receivers. He and others seem to have too hastily assumed that, because Edison had made a scientific experiment with an incandescent electric lamp having a metal plate sealed into the bulb, no invention was required to apply such an appliance as a receiver in wireless telegraphy.

Recent prolonged patent litigation in the United States between the Marconi Wireless Telegraph Company of America and the De Forest Radiotelephone and Teletelegraph Company has, however, cleared away misconceptions on this point. In the United States District Court of the Southern District of New York Judge Mayer, giving judgment on this matter last September, decided that the Fleming valve patent controlled the manufacture and sale of the de Forest audion, which was an electric glow-lamp thermionic receiver like the writer's oscillation valve, modified by the employment of a metal grid and a plate in place of a single plate. The audion was declared to be an infringement of the principal claims of the Fleming valve patent. The skilful attempt made by the defendants to construe the de Forest Bunsen burner patent as an anticipation of the writer's invention was dismissed by the judge who decided that this burner device had never been commercially used nor made any impression on the art, and that in so far as de Forest had produced any practical detector he had done so in consequence of knowledge gained from the Fleming specifications or scientific publications.

The judgment was not accepted by the defendants as final, and they therefore carried the case to the United States Circuit Court of Appeals by which judgment was given last month. Three judges unanimously affirmed the decree of the lower Court, and stated that the writer's application of an incandescent lamp with metal plate in the bulb as a detector of electric waves did involve invention in a patent sense and was not anticipated by de Forest or anyone else. They also declared that the Fleming patent was infringed by de Forest's audion or two-anode bulb.

PROPERTIES OF TWO-ANODE VALVE

Attention may, however, be directed to certain peculiar and useful properties of the two-anode valve which renders it capable of magnifying or amplifying electric oscillations. The usual method of working the valve with a single anode or plate is as follows: The electric waves falling on the aerial excite oscillations in it, and these are allowed to create other syntonic oscillations in an inductively coupled circuit comprising an inductance and a capacity. To the terminals of this last condeser is attached a circuit consisting of a telephone in series with an oscillation valve, which rectifies the oscillations as above described (Fig. 2).

In the case of the two-anode valve the filament in the bulb is surrounded by a grid or perforated plate and

*The Engineering Supplement of the London *Times*.

this again by a solid plate, the filament, grid, and plate being separated by vacuous spaces and all connected to separate terminals sealed through the glass bulb. Then for reception in wireless telegraphy the filament is rendered incandescent by an insulated battery, and one terminal of the filament and one of the grid are connected to the receiving circuit condenser (Fig. 3). A second battery has its negative terminal connected to the filament and its positive terminal to the plate, with insertion of a telephone receiver or other current-detect-

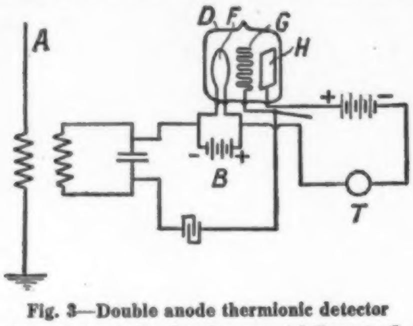


Fig. 3—Double anode thermionic detector
D, exhausted glass bulb; *F*, carbon or metal filament; *G*, grid; *H*, metal plate.

ing instrument. When the filament is incandescent this last battery can send a current of negative electricity across the vacuous space from the filament to the plate inside the bulb in virtue of the thermionic emission from the hot filament. If these electric oscillations are set up in the receiving circuit they are rectified as above described, and the grid acquires a negative potential or charge. This in turn operates to hinder the flow of negative electrons from the filament to the plate, but the peculiarity is that a very small negative current flowing from filament to grid may make a large variation in the negative current flowing from filament to plate.

Furthermore, if the two circuits external to the bulb—viz., the circuit connecting the filament and plate and that connecting the filament and grid—are inductively coupled through an induction coil, there can then be a mutual reaction between the currents in these circuits which sustains and exalts these currents so that an amplifying action results. Again, it is possible to join in series a number of such thermionic detectors so that the plate current of one is employed to create the grid current of the next, and hence to cause a still greater amplification. In this manner the thermionic detector which has been developed out of the single-anode Fleming valve has been proved to be the most sensitive radio-telegraphic detector of electric waves yet invented.

THE VALVE AS A GENERATOR

Finally, the two-anode valve may be used as a generator of continuous electrical oscillations by an action which resembles the experiment called the whistling telephone. If an ordinary Bell receiver is coupled to a carbon transmitter and the diaphragms are held near each other, the receiver emits a shrill sound. This is due to the sympathetic vibrations excited in the transmitter, which again in turn exalt the vibrations of the receiver. So with a two-anode valve, the grid and plate circuits can be coupled so that vibrations excited in one circuit are maintained by the energy drawn from the battery in the plate circuit. In this manner oscillation generators have been made for use in wireless telephony. This thermionic generation of oscillations is doubtless capable of great improvement, and constitutes a valuable addition to our resources in the development of radio-telephony.

Superheater Development in American Locomotives

By George L. Bourne

Of all the devices or improvements which have been introduced in American locomotive practice, the fire-tube superheater is by far the most notable. By its economy in fuel and water it brought the heaviest locomotive well within the capacity of the average fireman. Here was a device exactly suited to American practice—one with a low maintenance cost to fit in with the high wages of American mechanics; with increased boiler capacity of approximately 35 per cent, to act as a reservoir of power, ready for use when most needed; and finally, with a fuel economy of from 20 to 25 per cent.

As a result of the suitability of the superheater to American railroad requirements, there are today over 21,000 superheated locomotives in service or under construction in the United States and Canada. During the past year superheaters were applied to approximately 95 per cent of all the standard-gage steam locomotives built in the United States.

The general trend of superheating engineers has been toward a higher superheat—increasing the gas area available for superheat at the expense of the boiler tubes. This, it is true, tends toward a lower boiler efficiency on account of the necessary loss in water-heating surface, but the resultant increase in the efficiency of the entire machine offsets this many times over.

The results obtained on the Long Island and Lehigh Valley Railroads, which have used steam at a temperature in excess of 750 deg. fahr., have clearly demonstrated the possibilities of higher steam temperatures. As 200 deg. of superheat is amply sufficient to overcome condensation losses in the steam pipes, valves and cylinders, it is evident that the increased efficiency obtained by any superheat in excess of 200 deg. fahr. must be entirely due to increased volume of the steam per unit of weight. This is an almost constant increase in volume for each degree of temperature, and as far as calculations have been worked out for superheated steam, there is no limit to this increase. There can be no doubt that the limit of superheated steam temperatures for the most economical and efficient operation is only fixed by the ability of the exposed machine parts to withstand the higher temperatures.

While superheated steam was originally regarded as of benefit, primarily, to heavy road locomotives using steam for long, continuous periods, later developments have proved its desirability for the more efficient operation of locomotives in all classes of service. Perhaps the most notable example of this tendency is in the superheating of switching locomotives. While the degree of superheat obtained in switching service is naturally not as high as on road engines, it is, nevertheless, enough to reduce condensation losses greatly, which in this class of service amount to over 40 per cent of the total energy developed by the boiler.

As a result, there are today over 1,300 switch engines which have been equipped with superheaters, and a steadily greater proportion of the switching locomotives built are being superheated. It is significant in this connection to note that those railroads which have made a trial of superheated switch engines are now foremost in applying superheaters to their existing yard power.

The original design of the fire-tube superheater was so sound that comparatively few changes have been necessary in adapting it to the peculiar requirements of American railroads. But there have been certain modifications which, although of a minor character, are nevertheless worthy of attention.

The first important change was in the redesign of the through-bolt header. Experience showed that the original design gave entire satisfaction when correctly manufactured, but to furnish insurance against inferior material or improper methods in casting, a new design was prepared in order to counteract, as far as possible, the results of possible errors made in manufacture. In the new through-bolt header an additional air space has been provided between the walls of the superheated and saturated compartments in order to protect the casting from the rapid transfer of heat between these compartments, as insurance against the development of cracks between the unit seats in the lower face of the header.

The second great advance was the improvement in the design of the unit return bend. This consisted in producing a welded return bend to replace the original cast-steel bend, with consequent elimination of all mechanical joints in the unit. This machine-forged return bend, which is now almost ready for the market, will have a heat resistance equal at least to that of the old cast-steel return bend. At the same time it will have all the advantages which go with freer steam passages and a minimum restriction to the flow of gases through the superheater flues, with the complete elimination of all leakage due to threaded connections in the unit.—*Journal of the Society of Mechanical Engineering.*

Origin of Pyrite

The origin of pyrite in coal has been the subject of some speculation. With reference to this, it is to be noted that underground circulating waters may contain considerable amounts of iron salts, hydrogen sulphide, and gypsum and other salts in solution, which will deposit or precipitate under favorable conditions. Such conditions are furnished by the reducing tendencies of the carbonaceous matter in the coal and by the more porous layers of the seam which furnish easy channels of circulation for the solutions. The firmer bands of the seam tend to define and to limit these channels. Deposition having started around some favorable nucleus, further deposition tends to enlarge the particle. When the solution contains iron and sulphur compounds, the final result will be nodules, bands, or lenses of pyrite. Less resistance usually has been offered to the growth of these masses along the bedding or lamination planes of the coal than in other planes. For this reason pyrite bands are horizontal in the bed and may be either flat or slightly lenticular in shape. Often the bands are as much as one or two inches in vertical thickness, and they may have horizontal area of many square feet. The lenses are sometimes five or six inches in the vertical dimension and considerably greater in the lineal dimension along the bed.

It is a well demonstrated fact that all vegetable life requires and contains the element sulphur combined in the form of sulphates. Recent analyses have shown the amount contained to be far greater than was formerly supposed. Since sulphur was probably contained in the vegetable matter forming the coal substance and since certain bacteria have the power of extracting sulphur from sulphate, it is reasonable to ascribe such a biochemical origin to at least part of the sulphur found in coal. —From Bulletin No. 51 of the Engineering Experiment Station of the University of Illinois.

Electric Shock vs. Electric Burns*

The two types of electrical injuries encountered in the industries are electric shock and electric burns.

In electric shock, the patient becomes a part of the circuit, the current being transmitted through his body. The internal path of the electric current through the patient's body may become established without visible burning or with a mere puncture burn.

In electric burns, the patient's body comes in too close proximity to an electric arc. Such electric burns are the result of heat energy—they are thermoelectric burns. Other burns, as arise from arcing and electric welding, of which "flashed eyes" is a type, are due to the actinic rays of the electric arc, the patient being too remote to experience thermic burns.

In the case of short circuits, where the patient's body is interposed between the two lines, or between one side and ground, the patient's body then completes the circuit. There may be an imperfect contact, in which case an arcing distance intervenes; if hand to hand, both hands may be burned; if hand to foot, then burns may be found on both extremities, those on the feet often following the nails of the shoes.

When the circuit thus becomes completed through the patient's body with an intervening arcing space, both electric shock and burns may ensue. The human body, serving in this manner as a short circuiting medium, completes the circuit; the amount of current transmitted depends on the electric resistance of the body and the nature of the contact. The greater the intervening arc, or arcs, the less current there is available to penetrate the body. Since the human body is in series with the arc, produced by poor contact, a considerable voltage (or pressure) drop may occur in the arc, or arcs—the body, accordingly, being subjected to a relatively moderate shock. It is this fact that makes efforts at resuscitation so successful in the vast majority of cases.

While electric shock and burns are usually associated they are thus seen to be essentially different. Persons, without discoverable electric burns may indeed be fatally injured, and, conversely, persons frightfully burned may suffer less from electric shock, because, as results of the electric arcing, there is a considerable voltage drop in the arc, as just related, and because the coagulation necrosis, and charring of the burned tissues, apparently block the flow of the current through the patient's body.

The skin resistance of the human body is relatively high, measuring approximately 4,000 ohms. The dry calloused palms of a workingman afford a much higher electrical resistance. No accurate figures can be given, as different individuals vary in their response to electric currents, and the readings for the same individual will show variations.

The definite amount of electric current that may pass through the human body without danger to life has not been experimentally determined. The accidental electric contact injuries do not permit of the measurement of the amperage.

It is conceded, however, that one-tenth ampere of current passing through the body may become dangerous, one-fourth ampere may prove fatal, though seven to ten amperes are registered on the ammeter in criminal electrocutions.

It is thus apparent that the relatively high skin resistance of the human body is the element of safety in handling low-voltage lines. A moist skin, however, reduces the skin resistance.

Certain high-frequency currents are relatively safe because the current is confined to the surface of the skin. Low-frequency commercial currents, however, are prone to take an internal path.

When the skin resistance is broken, the current takes an internal path; a dangerous volume of current may then pass through the body, even at relatively low pressure. A momentary contact may result in no damage, yet the same contact, if prolonged, may result in serious injury.

*From a paper by Dr. C. A. Lauffer, of the Westinghouse Electric & Manufacturing Co. Read at a meeting of the National Safety Council.

The War's Effect on Merchant Shipbuilding—II*

The Standard Ship and Momentous Problems of Production

By Homer L. Ferguson[1]

Concluded from Scientific American Supplement, No. 2187, Page 339, December 1, 1917

I understand that in Philadelphia it is very difficult to have any of the shipyard employees excused from military service. Of course they have their own rules to go by in Washington, and we must all abide by them, but it is rather unfortunate that they should be differently interpreted in different parts of the country and it seems to me most unfortunate that the shipbuilders have been allowed to go to the front. The experience of England was that they had to take out of the trenches not only the shipyard workers but the ammunition workers and send them back to the factories again. It is a pity that we could not profit by that, but I suppose we will after we have gone a little further into the war. That would be a solution that would help very much with this laboring man difficulty. Of course the real trouble with the employers of labor is they are told that they must get together with the men and must have no trouble during this war; that they must keep the plant going. Every manager that I have talked with feels that it is incumbent on him as a good American to see that the wheels are kept going around and that these ships are produced, and I dare say that all the employers are perfectly willing that they should fight with their own laboring men and fight to a finish if need be, except at this time. We all know what that means. The demand is largely in excess of the supply of men. The sympathy of the Government is with the men. At our Navy Yard under the law we pay the going rate in that vicinity and arbitrarily fix the rate at a larger rate than the going rate in the vicinity which we have to meet, and we are told in case of difficulty we must keep going, so it is only a question that can be worked out by the Government's representatives and the shipyard employers together. I would be perfectly willing to see all the shipbuilders go down to the Navy Department and Shipping Board and say, "We will agree with you on these conditions and stand by them and will shut up our shop before we pay any more." Of course it can be said that a man who works is entitled to any wage he can get. Perhaps he is, but he is not entitled to stop working now, and he is not entitled to say that any other man shall not serve an apprenticeship now. He is not entitled to say that a helper shall not do a mechanic's work if he can do it. How perfectly ridiculous when a million and a half of the best young men that we have in the whole United States are serving an apprenticeship in the war, leaving their homes and going out to learn the art of soldiering in a very short time, and quite as difficult work to learn as riveting. What a ridiculous thing to say at a time like this that a man cannot get a job unless he has served his time at the trade, and tie the hands of the United States in this great war, which it must win if you and I are going to keep on being proud of living in the United States.

I was shown today in the case of a number of workers that the money which they could earn in a day was limited by the organization to which they belonged, and that if they earned that much money at two or three o'clock in the afternoon they would work no more, notwithstanding the fact that the management wanted them to do it. When will people ever learn that production by the use of labor-saving machinery to get a large production per man is all that gives us more than we ever would have otherwise or than we ever would have had before the days of large production? And yet they have limited production with the idea of giving more jobs to more men in time of war when we have not got enough men and have about three jobs for one man!

I will take just a little bit of your time in presenting what I might say is the worker's side of the story. I do not know the conditions in Philadelphia, but I imagine they are rather bad for laboring men. As an instance of what can happen, in Newport News, a town ordinarily of 30,000 people, we now have 55,000 people. The place is so full of people that no one can even go there to see the soldiers off. The condition of laboring men who are gradually coming in from the West to all the seaboard towns is a very difficult one, and a great deal of the basis of discontent is a lack of suitable housing conditions. That is ordinarily taken care of in the towns and cities by real estate people and those who build for investment, but at the present time that method is wholly inadequate, and this question will have to be considered along with the same program as that for our Army which is being installed in cantonments all over the United States. Why? Because we cannot find vacant houses for 20,000, 30,000 or 40,000 men in any one place, and so quarters have to be provided the same as for the soldiers. This new population is fitted to do more work, to do shipbuilding and build munitions or guns, and it is therefore necessary that it be brought from elsewhere and be not literally dumped on a community already overcrowded, but that proper living conditions and houses be provided at once. The Government is waking up to this in the case of some recent contracts let for destroyers. The Government itself will finance the building of barracks or temporary hotels for the men, so that several hundred can be housed at or near the shipyards where the work is to be done. For instance, in Philadelphia, you have large fabricated plants to be built, and you have a number of large war industries settled here. In addition, Essington will need probably 20,000 men and the fabricated shipyards probably 20,000 or 30,000 more. It becomes necessary even in this city, which is known all over the country as the best workmen's city in the United States, that the housing be looked into, and that large additional facilities be quickly provided. Men from the western part of this State will come here only by promise of decent homes where their wives and children may be properly cared for. That is a fairly simple thing, but it is a thing which has been neglected to an enormous extent, and one which will have to be rectified before we get far in the war program. One of the biggest problems England had was the formation of new communities and the building of whole towns. In some cases, they were almost ten miles square, and in them were provided not only ordinary houses and living accommodations, but public parks, playgrounds, theaters and everything needed in a modern town.

I cannot imagine the United States letting stand in its way any band of men whatever when the National honor and National life, in fact, depends on our winning this war, and when we are sending forth our young men and boys by the thousands to France.

The weakest point in the shipbuilding business is the forging situation, in my judgment. There are not enough forges in the United States to turn out all the forgings required for the shipbuilding. The great Bethlehem Company, Midvale, and the Allis-Chalmers are practically the only large ones we have, whereas Great Britain has twelve or fifteen very respectable forging concerns. It is absolutely necessary that some one determine whether this or that or the other kind of forgings shall be first; otherwise a lot of us are kept to end up with hulls but no machinery in them. It seems to me that we all want to do the best we can, but we would very much appreciate it if we could go to Washington and say to some one that this is the most important, and that is the next, and that is the next. Instead of that, we appeal from one Department to another and frequently end up with nothing.

We all know that it is a joy to have a few good mechanics and give them a job and forget about it, but we have to get away from that and to teach new people, which may fortunately be done with ships of standard makes and duplicate makes. The biggest problem that the employment managers have at the present time is to get hold of the best material possible, house it as decently as we can, and teach it shipbuilding as quickly as possible. The problem almost dazes one to contemplate. It can only be solved by bringing in enormous quantities of new men, and which must be done without any hindrance. The leaders of the unions have stated that they would allow this to be done. We have to do it, and no matter what else happens we must insist upon the right to break in any number of new men in the business. The Shipping Board will back it up, and I am sure that sooner or later the Administration itself will insist upon that being done on such a comprehensive scale as to make it possible for the United States to carry out its great shipbuilding program, which *must* be carried out.

*Abstract from an address delivered at a Joint Meeting of the Engineers' Club of Philadelphia and the Philadelphia Section, American Society of Mechanical Engineers. Published in the Journal of the Engineers' Club of Philadelphia.

[1]President of the Newport News Shipbuilding and Dry Dock Company.

The Cornish Gage

The *Ironmonger* gives an interesting and amusing account of a little instrument, the well-known "Cornish Gage," used in connection with mining screens. The account is as follows:

There has been hanging up over my desk for "donkeys' years" a small copper plate 6½ in. by 3 in. and marked "Cornish Gage." It is drilled with three rows of holes numbered 1 to 39, the first named being the biggest, and about 5-16 in. in diameter. No. 39 is no thicker than an embroidering needle. Quite recently an inquisitive visitor demanded a full account of its purpose. His question floored me; the fact is I had ceased to take any interest in the appliance, although there had been a time when it had been regarded as a puzzle. However, remembering that J. and F. Pool, whose name is struck on it, were still in business, I addressed a letter to them at Hayle, and in due course received the courteous reply which I print below.

"For about seventy years this firm has been supplying punched, round, butt, conical holes stamps battery screening to the mines in Cornwall and various parts of the world. The mine managers use the "Cornish Gage" as the standard to fix the size of the apertures in the screens. For example, a mine using, say, No. 35 hole screening, and desiring to change to the next size finer, would order No. 36 hole. For punched stamps battery screening the Cornish gage enjoys the same position as the Imperial standard wire gage does for wire.

"The foregoing briefly gives the information you desire, but it omits the history of the Cornish gage. Our senior principal, who is now eighty-two years of age, and has been in the business all his life, recalls many amusing stories of the good old days when customers used to make a day's holiday of bringing their screening orders to the works. As gages for the different sizes of holes, these jovial visitors would bring with them sundry nails or pieces of wood and the like, and by the time they had lunched their home-made gages were often mixed or missing, with results which must sometimes have been contrary to the customer's intentions when he was sober. Necessity being the mother of invention, and a suitable gage being an urgent necessity to enable orders to be correctly given after lunch, the "Cornish Gage" was devised by our firm, and standard gage in punched stamps battery screening."

Paraffin and Ambrine in the Treatment of Wounds

The method recently brought forward by Barthe for burns and frost-bites by the use of ambrine is a rational method of treatment for wounds in general, inasmuch as it affords an absolute protection for young epithelium. The special properties which its originator claimed for ambrine were a definite melting-point, a definite rate of cooling, tolerance of the tissues to its heat, and its retraction on cooling. Professor Masnata having made extensive experiments as regards the relative physical properties of ambrine and pure paraffin having a melting-point between 50° and 52° C., has come to the conclusion that the therapeutic properties of ambrine are due entirely to the paraffin.[1] He found that the paraffin formed a covering round wounds which adapted itself to the most minute sinuosities, protecting them efficiently and keping them immobile. The excellent results obtained by this method, he says, must be attributed to this property of paraffin of adapting itself to the tissues without adhering to them, so that when the dressing is removed there is no lesion to the superficial granulations nor the least trace of blood. The secretions find their way along the internal surface of the paraffin layer and are absorbed by the gauze at its edge. The absence of any irritation or injury to the wound facilitates to a marked degree the proliferation of epithelium, rendering the use of nitrate of silver to reduce exuberant granulations unnecessary. Professor Masnata made use of paraffin in a very similar manner to that advocated by Dr. Barthe for ambrine. The paraffin, which should have a melting-point of 50° to 52° C., is liquefied in a porcelain dish and raised to a temperature of 120°–150° for sterilization; it is then poured into a *bain-marie* and cooled to 70°–80° C., and kept at this temperature during use. After the wound has been cleansed with sterilized gauze and warm water it is dried, preferably by a current of hot-air from an electric apparatus, and then, by means of a large soft brush which has been sterilized by immersion in the heated paraffin, a layer is gently applied all over the surface. Absorbent wool and bandage complete the dressing. After-dressings are made every 24 hours or every two days, according to the amount of secretion; removal is easy as the layer of paraffin comes away with the wool and does not stick either to the skin or to the wound.—*The Lancet.*

[1]Policlinico, Surgical Section, June 15th, 1917.

Fig. 1.—The concrete ship being launched, bottom up

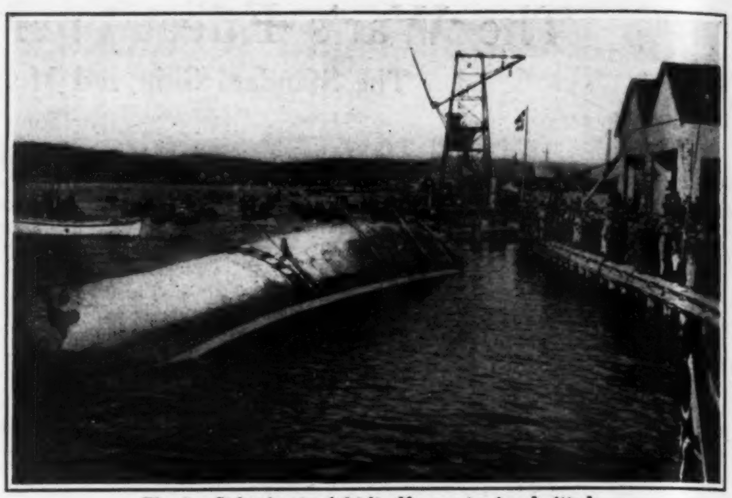


Fig. 2.—It begins to right itself as water is admitted

Ferro-Concrete Shipbuilding*

Recent Developments and Methods of Construction

Interest in ferro-concrete ships is greatly increasing, and it is satisfactory to learn that the Committee of Lloyd's Register of Shipping have approved plans for the construction of a number of such ships up to 500 tons deadweight capacity, after careful consideration and in the light thrown on the subject by the report of one of their surveyors upon a visit to works in Scandinavia, where, owing to exceptional circumstances due to the war, more work has been done in this new departure than in other countries. The attitude of Lloyd's is an important commendation of the principle, as the supervision of building operations for classification in their register, carrying as it does ensurance of underwriting, is certain to encourage the use of ferro-concrete as a constructional constituent for certain types of craft. Recognition of limitations and the influence of war conditions is justified, although the Committee of Lloyd's Register are not likely to enunciate any definite views. At the same time it is interesting to have the views of the organization in Norway which is somewhat analogous to Lloyd's, since opinion in that country is supported by a certain measure of practical experience, if influenced also by the absence of metals for shipbuilding and the need of rehabilitating the shipping fleet severely depleted by war losses.

A director of the Norwegian Veritas has lately given his views on the subject, unofficially. He was convinced, he said, that ferro-concrete, under normal conditions, would be used for lighters, floating docks, buoys and other floating objects where the weight did not play a very important part. As far as seagoing vessels were concerned, he was of opinion that the weight of ferro-concrete vessels would detract from their carrying capacity to such an extent that it would be difficult for them to compete against vessels built of steel in normal times. On the other hand they possessed a great momentary interest, as they offered a possibility of procuring some tonnage to make up for all the vessels that had been lost. He pointed out that more experience was necessary, and referred to a lengthy communication on the subject he—some weeks ago—had forwarded to the chairman of the Norwegian Veritas. In this he underlined the material difference between using ferro-concrete for lighters, as had been done in Italy for several years, and for seagoing vessels.

Experience from ferro-concrete constructions on shore is not directly applicable to vessels. Fixed structures, as a rule, are only subjected to a load the maximum of which is known, and which only acts in one direction, whereas the load to which a vessel may be exposed cannot be directly calculated, and its direction is constantly varying, especially in a turbulent sea. Under these circumstances, pending fresh experience, the strength of a ferro-concrete vessel must be determined by comparison with that of a steel vessel of the same type and dimensions. This, however, is a difficult problem, as a steel vessel, on account of peculiarities in its construction and building, in some directions may have more material than necessary from general strength considerations, and also because several qualities of concrete, which it is necessary to know in order to make fairly reliable comparisons with steel vessels, are not yet sufficiently ascertained. The actual building process of a ferro-concrete vessel is such that the quality of the material and the workmanship cannot be controlled with the certainty obtaining for steel vessels.

In connection with the strength of reinforced concrete it must be remembered that the tensile strength of concrete is very limited. Tensile stresses must, therefore, be carried, as far as possible, by the reinforcing steel. In a floating structure, however, the concrete cannot be altogether guarded from tensile stresses, which are apt to create small cracks. Such cracks may also arise during the setting of the concrete. On shore they are generally considered to be of minor importance, but it is by no means certain that such cracks may not play a different part in vessels exposed to varying stresses and the effect of penetrating salt water.

Fig. 5.—The interior mould upon which the concrete is laid to form the hull. The ship was built bottom up

As to the watertightness of cement, apart from cracks, this can probably be attained by using sufficient cement, by mixing certain chemical substances with the concrete, or by giving the vessel a waterproof coating. The life of a ferro-concrete vessel will no doubt to a great extent depend upon the chemical composition and watertightness of the concrete, on the proper placing of the reinforcement at a sufficient distance from the outside of the concrete and on the effect of salt water upon concrete and upon the reinforcement if there be cracks. Judging by experience gained from ferro-concrete quays, it may perhaps be assumed that the durability, when the necessary precautions are observed, will be satisfactory, but experience can alone settle this question. It will also be of interest to learn what effect waste oil in the motor-room will have, as oil is generally supposed to affect the strength of concrete in an unfavorable manner. In conclusion it must be remembered that the strength of concrete increases materially during the first months after mixing.

It is certain that a large number of ferro-concrete vessels will be built in Norway in addition to those already built, and therefore the classification societies will be obliged to take some action. It has therefore been suggested to the Norwegian Veritas that they should open a classification for ferro-concrete vessels, subject to certain precautions, as, for instance, a limitation of the waters to be navigated, and subject to the class in the register being defined as experimental.

At present it would be inadvisable to fix rules for the building of such vessels, and it should be left to the director to judge each case individually on its merits, until it can be ascertained how the methods of construction and building of such vessels are developing.

Meanwhile conditions favor the building of ferro-concrete ships in Norway, as elsewhere. The times are not normal; freights are very high, and it will be long before they fall to pre-war figures, and any vessel that will float and carry cargo may be relied upon to earn large profits. Steel plates and angles are difficult to obtain, while cement can scarcely find a market, and concrete aggregate is abundant. Ferro-concrete, with its moderate demands for steel, and that in the simplest form, therefore has attractions which have led to serious attempts to employ it in shipbuilding. Already encouraging results have been attained. On August 1st there took place the trial trip of the Norwegian vessel "Namsenfjord," with entirely satisfactory results. She is 84 feet long, 20 broad and 11.6 feet deep. The hull is monolithic with the deck and the frames round the hatches and those serving as foundation for the cabin aft. Outside the hull are two large wooden fenders. The vessel is admirably suited for the transport of timber, and is fitted with appliances for prompt loading and discharging and with a Bolinder motor. The vessel will be put on a Norwegian coasting route.

The Fougner yard has already commenced work on its eighteenth ferro-concrete floating structure, a floating dock, while several vessels up to 1,000 tons deadweight have been contracted for, besides a lightship for the Ildjern Shallow. A vessel ordered by the South Varanger Iron Ore Company will have double sides and bulkhead, being intended for the transport of ore, which does not take up much space. Sister companies of the Fougner Ferro-concrete Shipbuilding Company are in the course of formation in England and America. Provided the necessary raw materials can be obtained, the Norwegian yard can build some 30,000 tons a year.

The same day as the "Namsenfjord" was launched from the Moss yard the first ferro-concrete lighter, "Beton I," was launched from the Porsgrund Cement Works. The launch was particularly interesting from the manner in which it took place, inasmuch as the lighter was sent into the water bottom upwards. This

*From *Engineering*.

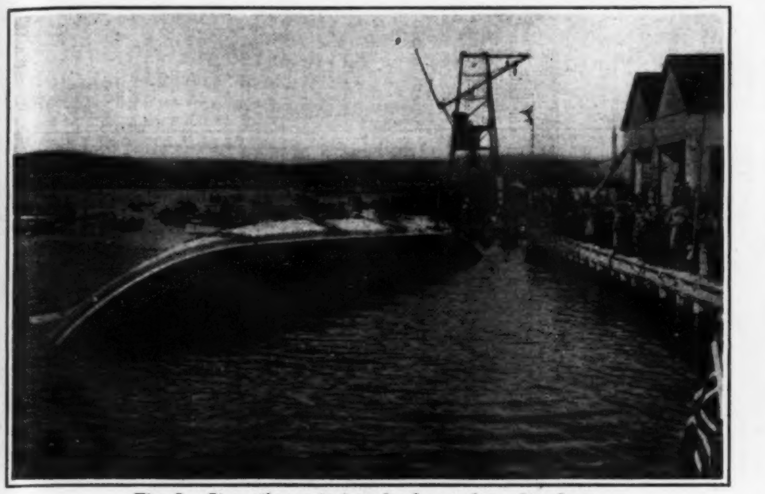


Fig. 3.—It continues to turn by force of gravity alone

Fig. 4.—The hull in proper position, but full of water

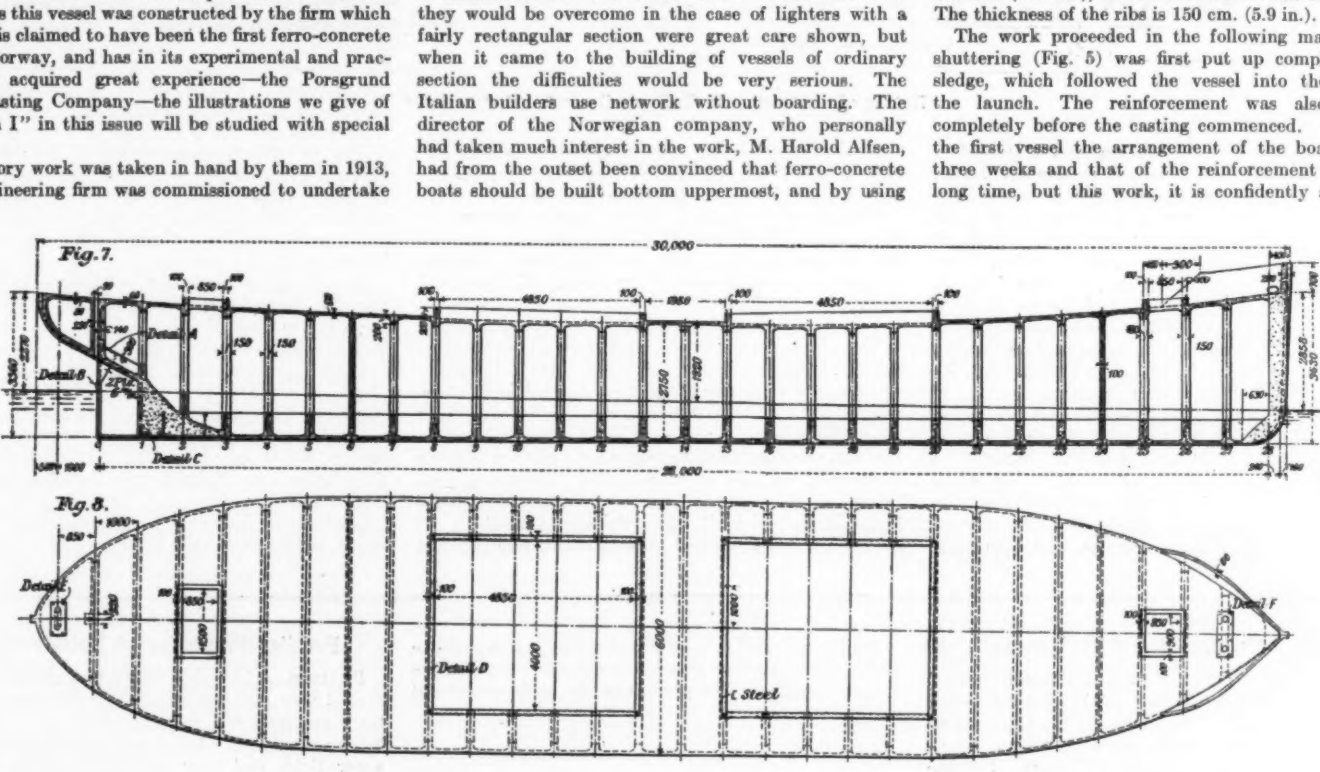
was done in accordance with calculations undertaken by the director of the company, and these were entirely borne out by the way in which the lighter, in less than twenty minutes, righted itself, floating on its keel in the usual manner. The lighter has a capacity of 200 tons deadweight and is to have a 70-h.p. Skandia motor installed. As this vessel was constructed by the firm which built what is claimed to have been the first ferro-concrete vessel in Norway, and has in its experimental and practical work acquired great experience—the Porsgrund Cement Casting Company—the illustrations we give of the "Beton I" in this issue will be studied with special interest.

Preparatory work was taken in hand by them in 1913, and an engineering firm was commissioned to undertake the necessary calculations. Designs were prepared for lighters of different types and sizes, but building work was not proceeded with at the time, the company being very fully employed otherwise. In 1915 a bridge pontoon of reinforced concrete was built for the Porsgrund municipality after the design of the same engineers. The pontoon was of the following dimensions: length, 16 m. (52 ft. 6 in.); breadth, 5 m. (16 ft. 4.8 in.); and height, 2 m. (6 ft. 6.7 in.). It had a deck fore and aft and two watertight bulkheads. The casting was done with double boarding in the walls. The bottom and sides, with ribs and bottom girders, were cast between 6 a. m. and 10 p.m. on one day. The deck was formed during the next forenoon. Twenty men were at work, and the casting was pushed ahead as fast as possible so as to avoid any faults in the concrete. The mixture was 1:3, with small cobbles only in the ribs; the walls were 5 cm. (1.97 in.) thick. The pontoon was not polished, as it proved watertight without this being done. The experiences resulting from this first enterprise established the very considerable difficulties connected with double boarding. It was a troublesome task properly to arrange the reinforcement, and there was no actual guarantee that the iron would be in the right positions. The casting itself entailed a good deal of trouble, and the greatest care had to be taken to make sure that it was thoroughly well done. The most difficult points were those where sides and ribs adjoined the bottom. As a matter of fact it was found that in one or two places there were faults in the casting, which had to be remedied.

The pontoon is now used, as it was originally intended to be, as a supporting pontoon, but was first employed for the transport of sand and other material, and thus it is claimed for it that was the first ferro-concrete vessel or craft built in Norway.

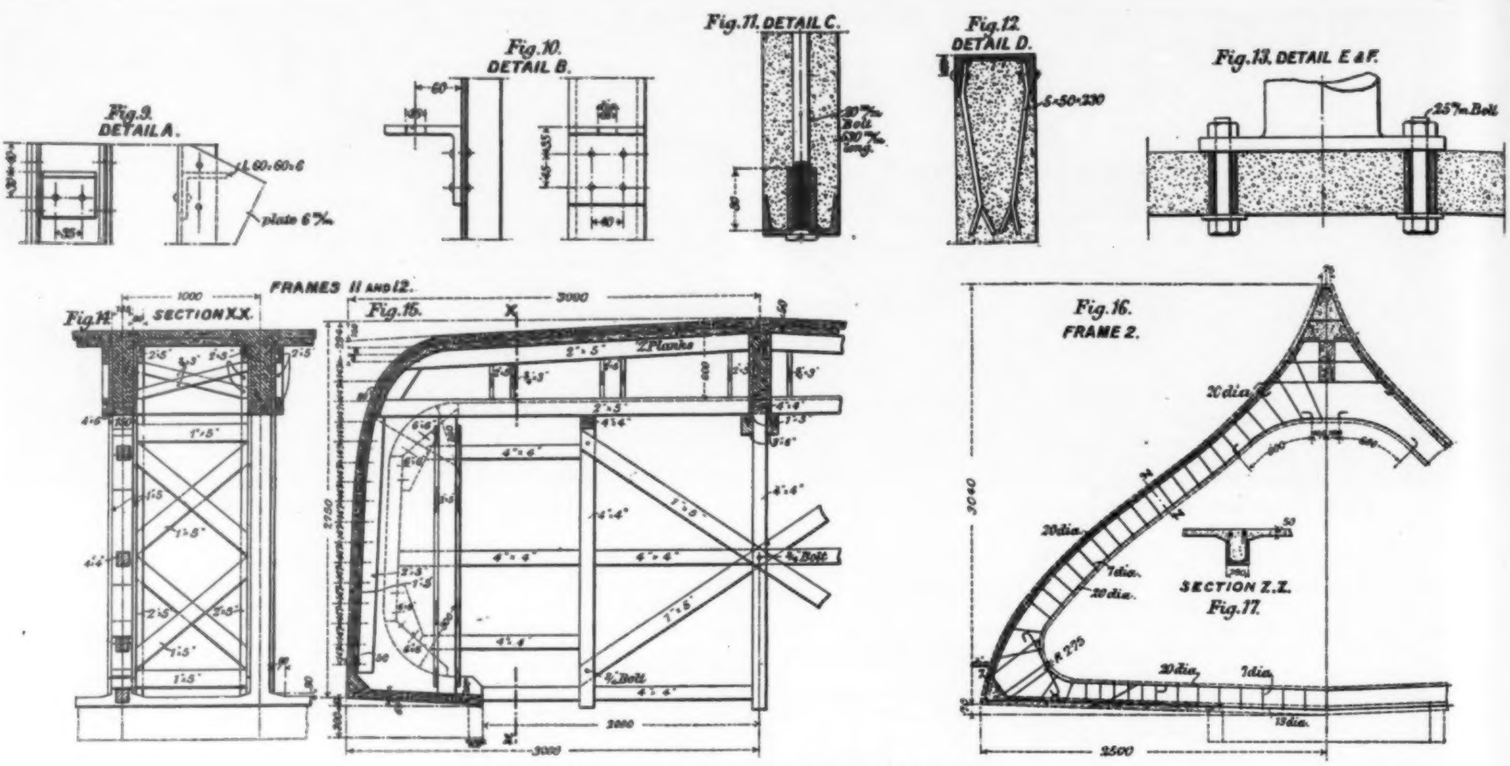
Consideration of the difficulties led to the belief that they would be overcome in the case of lighters with a fairly rectangular section were great care shown, but when it came to the building of vessels of ordinary section the difficulties would be very serious. The Italian builders use network without boarding. The director of the Norwegian company, who personally had taken much interest in the work, M. Harold Alfsen, had from the outset been convinced that ferro-concrete boats should be built bottom uppermost, and by using only an inner shuttering, or only outer boarding, as far as the vertical sides were concerned. In order to do this, however, the problem of how to turn a boat of fair dimensions upright had to be solved. The solution was found last year, and consists in letting the boat take the water bottom upward, in the position in which it is cast.

The details show what is called the Alfsen method applied to this "Beton I"—a 200-ton deadweight carrying motor vessel. The calculations and design were prepared by the engineers, Messrs. Bonde and Norman, already referred to, the line drawings being entrusted to a ship constructor. The general dimensions are given on the drawings. The previous calculations for the lighters and the pontoons could no longer be used, these being intended for inland waters and river traffic. For seagoing vessels altogether different stresses had to be reckoned with. As it turned out, the reinforcement for the latter had to be more than 50 per cent heavier than for the lighters at the same time the rib and girder dimensions had to be materially increased. A very "fat" mixture was decided upon, without any cobbles being used. The thickness of the walls was fixed at 50 cm. (1.97 in.), the depth of the ribs in the bottom at 600 cm. (23.6 in.), and in the sides at 250 cm. (9.8 in.). The thickness of the ribs is 150 cm. (5.9 in.).



The work proceeded in the following manner. The shuttering (Fig. 5) was first put up completely on a sledge, which followed the vessel into the water at the launch. The reinforcement was also arranged completely before the casting commenced. In building the first vessel the arrangement of the boarding took three weeks and that of the reinforcement an equally long time, but this work, it is confidently anticipated, can be done in half the time for the next vessel. The casting itself was got through in two days, it being commenced early Thursday morning, July 26th, and the casting of the concrete was finished at 6 o'clock on the following afternoon. Any after-polish was entirely completed at noon on the Saturday. A period of three weeks was allowed for the concrete to set on account of the strong mixture (1:2), and it may be taken that a vessel of this size can be built every six weeks on each slip. During the greater part of the casting 60 men were employed, for a short time 55 sufficed. The concrete filling and the polish were partly done by hand and partly by compressed air appliances constructed by the company. The shuttering was made of strongly dimensioned material arranged in such a way that it was easy to detach it and put it together again for many succeeding vessels.

We give four illustrations of the launch of the ferro-concrete ship "Beton I." The feature of the launch is associated with the fact that, for facility in arranging the reinforcement of the concrete, the vessel was built bottom upwards, and the platform on which it was completed was sent down the ways, as shown in Fig. 1, the three successsive views as given above illustrating the progress of uprighting after the vessel had floated. In order to ascertain the different phases and conditions of the process, M. Alfsen undertook a number of experiments with a model, and Figs. 23 to 27 show diagrammatically the successive stages in the uprighting of the ship.



Details of construction of the Ferro-Concrete ship "Beton I"

Care had to be exercised to ensure that, in launching, the vessel, from being stable, should become the reverse, or nearly so; thus the uprighting took place automatically, or by using very little power. The main principle was that the air under the "arch" should be partly released. The accompanying diagrams show the course of the uprighting in principle. Figs. 1 and 23 shows the boat as it has just reached the water. It is at that point stable. The air was then let out, and water was admitted into the vessel, thus destroying the stability by reducing the water-line, as shown in Fig. 24. The vessel then was in an unstable condition, gravity, as represented by 7 in Fig. 25, being above buoyancy, represented by 8, and an upsetting couple being introduced, as shown in Figs. 2, 3 and 26, brought the vessel to the upright position, as shown in Figs. 4 and 27. The uprighting, to begin with proceeded slowly, in the intermediate position it accelerated, the working moment at that point being greatest, and then again more slowly, until the moment becomes zero. The turning took place very neatly, without any shock, and the vessel had then of course to be emptied.

The launch of "Beton I" took place in the presence of a distinguished gathering including the Premier, Mr. Gumar Knudsen, and the "provision" minister (a new post, an outcome of the times), M. Oddmund Vick. The hull looked bright and shapely on its cradle, on which were placed a number of sandbags, intended to keep down the cradle when the vessel glided out from the slip. The hull looked like a big whale in its proper element, and a number of workmen, headed by the foreman, went on to the hull to open the circulation pipes, of which there were four on each side. The air began to flow out, the vessel began to lean over to port, and shortly afterwards, on the starboard side, the counter rail became visible above the water. In a few minutes the hull had righted itself. The Premier, himself an old engineer, much interested in engineering exploits, and a large shipowner, at a subsequent gathering made a complimentary speech in which he congratulated M. Alfsen on the extremely successful and interesting launch according to his new method, and stated that the ferro-concrete shipbuilding industry might become of vital importance to the country.

The Porsgrund company looks upon it as essential that this class of shipbuilding should be carried out on an extensive scale of the standard types which may be chosen, and no doubt is entertained as to it being possible to build vessels extremely quickly and cheaply on these principles. The company intends to build, by degrees, larger and large vessels, fully fit and seaworthy for over-sea traffic. A subsidiary company, working on the same patents, has already been started for western Norway at Ytre Arne, near Bergen; the installations are being pushed ahead, and the first ferro-concrete vessels from that yard are expected to be taken in hand shortly and aeady for delivery within a few months.

Solving the Theorem of Pythagoras

In December, 1910, we presented eighteen distinct demonstrations of the theorem of Pythagoras stating that in a right triangle the square on the hypothenuse equals the sum of the squares on the two legs. These were contributed by Mr. Arthur R. Colburn, of Washington, D. C. We learn from Mr. Colburn that he has now reached number 91 in his series—an altogether remarkable record, and one which testifies equally to the ingenuity of our correspondent and the richness and flexibility of geometry.

Of course the value of this sort of thing lies not in the repeated proof of the same fact, but in the exhibition which it gives of the effective marshalling and use of the elements of proof, and perhaps even more in the better insight which it gives into the interdependence of the various theorems of geometry. We show herewith one of Mr. Colburn's demonstrations—his serial number 79 which is of especial interest in this way.

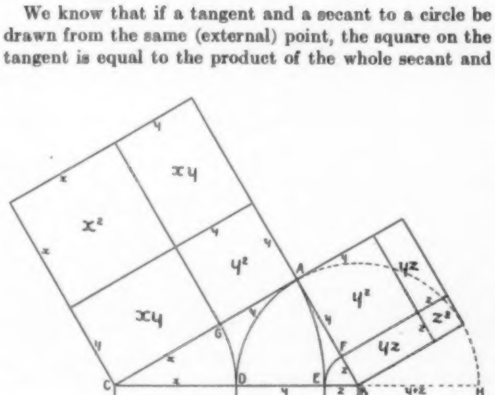
Given the triangle A B C, with the right angle at A.

To prove that the square on A B × the square on A C = the square on B C.

Complete these squares. From B as a center strike the arc A D, and from C as a center the arc A E. From B as center strike the arc E F, and from C as a center the arc D G. Divide the other sides of the squares in the ratios determine by points D, E, F and G, as indicated, and to the three distinct line-lengths present attach the values x, y, z, as in the figure. The correctness of the values attached follows from the construction, as does that of the values shown for the various rectangular areas.

The areas into which the square on the hypotenuse is divided correspond to those into which the two squares on the legs are divided, except that in the one case we have y^2 and in the other $2xz$. A proof that $y^2 = 2xz$ will therefore establish the Pythagorean theorem.

We know that if a tangent and a secant to a circle be drawn from the same (external) point, the square on the tangent is equal to the product of the whole secant and



the portion of the secant outside the circle. We apply this to the present figure, arc A D being the circle, line C A the tangent, and line C B (extended to a point H, lying y+z beyond B) the secant.

Then $C D \times C H = C A^2$

$$X (X+2y+2z) = (X \times y)^2$$

$$X^2+2xy+2xz = X^2+2xy+y^2$$

$$2xz = y^2$$

Q. E. D.

Peculiar Properties of Rubber Sponges

Because of its cellular structure rubber sponge has several very peculiar properties. For example: it has the lowest apparent specific gravity of all solid bodies, being around 0.05. In spite of its cellular structure it is water tight, and very nearly gas tight. While it is honeycombed with minute cells, each cell is an individual unit and the rate of diffusion of gases through it is comparatively low. Because of its low specific gravity it has a very low specific volume, which thus brings its cost within range for common purposes. Perhaps one of the most important uses to which it has been put is in the preparation of life preservers. It will not waterlog, is light, conforms easily to the lines of the body, and is not to be ruined by a pin prick. A life raft made with rubber sponge is as near fool-proof as one can be. All sorts of floating devices, such as buoys, markers, etc., may be improved by its use.—*Metallurgical and Chemical Engineering*.

French Army Helmet

During the recent session of the medical and surgical department of the French army, several communications were made upon the efficacy of the present steel helmet. The army surgeons Bouquet-Roulland and Fournestraux presented a series of observations in which they showed that the helmet is a most efficacious protection for the wearer, and that a considerable number of lives have been saved since its introduction into the military equipment. One case presented by Dr. Broquet is especially noteworthy, and he cites the fact that a rifle ball fired from 6,000 feet distance arriving with full force at an angle of 45 degrees was deflected by the helmet without other damage than a slight wound on the surface of the scalp. Numerous other cases where lives were saved were reported at the session.—*New York Herald*.

The Human Factor*

The business of an engineer is to deal objectively with material problems; his training consists in the acquisition of knowledge to this end. Curiously enough, the subject of labor is later to become almost the dominant and possibly the most troublesome of all his cares. Starting with a belief that his main object is the production of mechanism from material, he finds that, as time passes, he is much more concerned with finance, labor and the human factor—commercial or manual. He becomes more an administrator than a technical executive, realizes that selection of subordinates and the will to work of his staff—both psychological problems—are more potent matters even than organization and purchase of material. Human muscle—that is, its external appearance—is easily viewed, but the intelligence and capacity which, after all, animate it, are not so readily assessed. Capital and labor associated with system and organization—the marriage of credit and muscle—is too often superficially assumed to be a profit-making copartnership. Provided sufficient of either is available, there should be little difficulty in earning dividends seems a usual view. The human factor, however, permeates the entire structure, and unless duly assessed and rightly placed, the anticipated profits may vanish unaccountably into thin air. It is too little realized that while share capital is definite, each human unit is a separate personal identity afflicted thereby with common human disabilities.

In actual practice there is only one penalty for failure or infraction of discipline—dismissal. On the other hand, no firm can afford for trivial cause to deprive itself of the services of a potential profit-earner; it would suffer a greater loss than that immediately realized, as change disturbs the poise and balance of the machine. The power of inflicting the extreme penalty is therefore more or less judicially exercised; first thought is often tempered with discretion. The outcome is that the two things—power and penalty—tend to equate each other. The man is kept in check by knowledge of the penalty, the management, knowing the difficulty of adequate replacement, is none too ready to use its privilege. Fear on both sides helps to keep each virtuous.

Technical troubles are apt to cause less serious problems than the human factor. It is an incomparable asset to be able without resentment to get the most out of a working force; to possess the knack of so doing is not a common quality. To diagnose the slacker may be easy, to understand why he slacks not so simple, to apply the correct remedy more difficult still. It is safe to say that a policy of bluff or of blackguardism is as likely to be wrong as continuous nagging or fault-finding. To handle an awkward case by tact and firmness, by the hand of steel in the glove of velvet, requires experience no less than natural ability. Some men possess this happy faculty, which keeps a sore place from rankling. To drop heavily on the wrong man, or for the wrong matter in the wrong way, displays a want of judicial insight and is fraught with perilous results to output. A man flagrantly caught out will suffer remarks and feel their caustic justice without subsequent resentment. To use the same method for purely accidental fault is to invite shrinking. We are, after all, each a member of a common human family, and whatever station we occupy our feelings are roughly equal. Any method whereby effort is induced is an end in itself worth consideration and some thought.

In normal times men often are hired, tried, and fired, at the wanton caprice of a technically capable but otherwise ill-equipped individual, because an excess supply of labor is available. With a restricted supply an explanation of the touchiness of labor complained of just now in some quarters is afforded. The men are not rightly handled. To keep a large staff working harmoniously to a single end demands administrative ability of a high order. Judicious and just handling is of prime importance, the appearance of injustice, no less than a flagrant case of it, must be strictly avoided.

Profit-making is the cream on the milk of industry, it represents only a fraction of the bulk turnover, and it may be forfeited in many ways. System and organization is one part of the profit-earning mechanism, the correct handling of labor and its incitement to real effort are quite as important and not so apparent. To reach the desired end needs a judicial temperament coupled to an endowment of common-sense, scientific spirit and a frank recognition of labor's human structure.

There are productive and unproductive periods in each working day, alternations of normal effort and natural slackness. It is the dead centers which want attention, not the time of full crank effort. Conditions and environment have much to do with output. A difference of 10 degrees in temperature unrectified will produce remarkable results. Fresh air and light, the former costing nothing, do much to affect the total output. The human dislike of sheer monotony, its desire for rational change, are other questions for consideration. Piecework is one incentive, sheer interest in the job in hand another. If the shop recognize in its chief an able man, competent and efficient, the results will exceed those under the reverse conditions where and when they operate. Example does more than driving, as shown in the success achieved in many small concerns.

Production is a delicately-poised balance dependent upon quite small things, which in the aggregate are apt to turn the scale. Labor is generally found to be more troublesome where the supply is strictly limited; then the necessity for right handling is more acute, and as a consequence the result is usually better and the staff more satisfied. The inevitable result of scarcity is an increase in realized value; reduced supply may result in insubordination or, if the firm is wise, in improved conditions and better treatment. The intimate relation of isolated factory, scarcity of labor and welfare schemes point their own moral. The worst industrial conditions are found in large centers, where both man and management have a greater available choice. The necessity for better conditions is less apparent and certainly less realized. Labor trouble points to a lack of visualization on the part of the management, to the desire on the part of the man to pick and choose, that is, to find an open market for his skill, or to injudicious handling, pointing to faulty executive.

Belief on the part of the man that he will meet with rational justice from his employer who, he feels, is human and personally interested in his work, tends to retain skill and competency, even when offered better terms elsewhere. More than one highly qualified producer has failed because of his inability to understand men other than as numerals or portions of an essential mechanism. Exploitation or unfair treatment, or possibly dismissal for small reason in the case of a single individual, shakes the confidence of the rest; the coördination of a labor force and their dependence in daily work one on another lend fatal prominence to a seemingly minor issue. A small grievance is like a gear wheel with a damaged tooth, which disturbs the smooth running of the train. The hostility and independence shown in labor troubles, the divorce of the men from the interests common to the firm as a whole, have been at least partly made and fostered by such causes. Confidence once lost is not easily restored. Like reputation, it represents a solid asset, and any effort to engender more cordial relations is worth the making, while the result is likely to be more beneficial than is often realized and well worth the trouble involved.

*From *Engineering*.

Diderot's Encyclopedia

The United Engineering Society Library has been fortunate in securing a well-preserved copy of the famous French "Encyclopédie" edited by Denis Diderot (Encyclopédie, ou Dictionnaire Raisonné des Sciences, des Arts et des Métiers, par une société de gens de Lettres. Mis en Ordré & publié par M. Diderot; & quant a la Partie Mathématique, par M. d'Alembert . . . 3rd éd. Geneve, Pellet, 1777-1779. 36v., fronts, ports, tables. With 3v. of copper plates). The Encyclopedia Britannica characterizes this work as one of "greatest and most remarkable enterprises of the 18th century." The germ of the "Dictionnaire" originated in a plan to translate from English into French, Ephraim Chambers' "Cyclopædia," or an Universal Dictionary of Art and Sciences, containing an Explication of the Terms and an Account of the Things Signified thereby in the Several Arts, and the several Sciences, Human and Divine." (London, 1728. 2v.)

After much quarreling between the publisher and those who had undertaken the translation, it was abandoned. An original French work was then planned and Diderot engaged as editor. "Instead of a mere reproduction of Chambers, he persuaded the bookseller to enter upon a new work, which should collect under one roof all the active writers, all the new ideas, all the new knowledge, that were then moving the cultivated class to its depths."

No other encyclopedia, it is safe to say, ever had so stormy, so romantic, and eventful a career. The work was by no means a piece of closet scholarship. Into it was poured the spirit of the democratic and scientific movement just preceding the French Revolution. The encyclopedia burns with the desire of the men of that time to conquer nature. It is aflame with the passion for experiment and exploration. Needless to say, it met with the violent opposition of the powerful ecclesiastics and the despotic French court, who instinctively felt this work to be a menace to blind faith in the traditional explanations of natural phenomena and a challenge of the unthinking worship of autocratic authority. Rousseau wrote the articles on music. Montesquieu, Turgot, and Voltaire were among the more than twenty contributors. Such a galaxy of free spirits did not inspire the trust of the then tottering French feudalism. In 1749 Diderot was imprisoned at Vincennes in close confinement for 28 days, and cooped up in the castle an additional three months and ten days. The first two volumes of the encyclopedia were suppressed "as being dangerous to the king's authority and religion." The plates were ordered seized but could not be found. After work had been resumed, the Parliament of Paris, in 1759, stopped the sale of the Encyclopédie and ordered all copies to be burned. In 1766 Lebreton, the publisher, was forced to show his subscription list and was put in the Bastile for eight days. The famous beauty, Madame de Pompadour, who had befriended the undertaking from the first, pleaded for the lifting of the ban upon it, saying to the king that she could "know no longer how her rouge and silk stockings were made. The duc de la Vallière regretted that the king had confiscated their encyclopedias, which could decide everything. The king said he had been told that the work was dangerous, but as he wished to judge for himself, he sent for a copy. Three servents with difficulty brought in the 21 volumes. The company found everything they looked for, and the king allowed the confiscated copies to be returned." Lebreton, the publisher, set up the copy exactly as it came from the editor, but after final revision secretly removed all parts he felt too bold. It was thus that this great scientific work fared.

Diderot was the contributor of articles on philosophy, the arts and trades. "He passed whole days in workshops, and began by examining a machine carefully, then he had it taken apart and put together again, then he watched it at work, and lastly worked it himself. He thus learned to use such complicated machines as the stocking- and cut-velvet looms." The copper plates of this set are most excellent. They are valuable as records of the early history of the machinery from which the factory system of today has been developed. The whole work illumines the dawn of the modern world, the age of engineering.

Engineers of today are so busy making history, that they have little time to write it. But there are those who take a deep interest in tracing the development of their various professions. The United Engineering Society Library exists primarily as a working tool for the man in active practice. However, through the generosity of its friends, it has received some rare collections of books, such as the Wheeler and Raymond gifts, and is yearly becoming stronger in source material on engineering history. The "Encyclopédie" of Diderot is regarded as a noteworthy addition.—*Journal of the American Society of Mechanical Engineers.*

Use of Hydrogen Peroxide in the Brewery

Hydrogen peroxide has been successfully applied to the disinfection of casks, filter pulp, and other objects in the brewery. Casks which have become mouldy are steamed for about fifteen minutes, and then 1 quart or in bad cases more, of 12-volumes hydrogen peroxide, diluted to 1 gallon, is introduced into each; the casks are closed and rolled thoroughly at intervals during several hours. The peroxide penetrates deeply into the wood, destroying moulds and other organisms; it has no injurious action on the wood and leaves no undesirable decomposition products. In the treatment of filter-pulp, this is first washed with cold water and then with water at 160 degrees F. (71 degrees C.); after cooling to about 120 degrees F. (49 degrees C.), 2 quarts of 12-volume peroxide is added for about 25 pounds of pulp. After standing for half an hour the pulp can be used; it is white and quite sterile. Wooden stoppers are put through an ordinary washing machine and then left for several hours in 12-volume hydrogen peroxide diluted eight-fold.—H. B. Wooldridge in J. Inst. Brew. From a note in the *Journal of the Society of Chemical Industry.*

Economy in Bread-Making

With the price of wheat still rising, it is interesting to learn that a new process of bread-making, direct from the kernal, without the preliminary conversion into flour, is in operation in the municipal bakery at Bergamo (Italy). The wheat, which must be first thoroughly cleaned, is then soaked in hot water for twenty-four hours, more or less, according to its degree of hardness. During this time it commences to germinate and undergo a complete transformation. This pasty mass is next kneaded into dough, yeast is then added, and the whole worked up to the proper consistency, allowed to rise, then formed into loaves, and baked in the oven in the usual manner. Bread made in this way is said to be quite as palatable and far more nourishing than the ordinary wholemeal article, containing as it does all the constituent parts of the wheat. It is claimed, moreover, that a saving of 25 per cent in the cost of bread-making is effected by this direct process, and at the same time a larger yield from the grain is obtained.—*Journal of the Royal Society of Arts.*

Military Aircraft and Their Armament

Tactical Maneuvers and Developments That Have Resulted

By Jean Abel Lefranc*

The technical elements to be considered in aerial combat are based upon the qualities of the aeroplanes engaged, such as armament, speed, facility in handling, altitude capability, etc. These tactical and technical elements may be divided into two sorts, which though very different are intimately connected.

The combat begins by a series of tactical maneuvers by means of which the assailant seeks to get as many initial advantages on his own side as possible, by surprise, by a greater altitude, by a group attack, by a rear attack, etc. It is ended by the actual contest between the machines, continued till one side or the other is destroyed or put to flight.

It is evident that the preliminary tactics can be executed only if the technical qualities of the avion make them possible. Freedom to choose between engaging in combat or avoiding it implies superiority of speed. If the machine possesses the four technical superiorities of the ideal airplane, speed, climbing, armament, ease of handling, then its pilot has all the tactical advantages on his side.

But an airplane may have a single one of these technical superiorities yet be unable to gain any tactical advantage therefrom. For example, the Voisin gun-airplane, with its 37 caliber rapid fire guns was superior in armament to most of the enemy airplanes of that period; but since it had no speed, was not easy to manage, and could not rise, in practice, above a height of 2,500 meters (8,125 feet), it was almost never able to profit by its advantage of armament. The enemy airplanes profited by their speed and facility of management to attack it without getting within its very limited range, their superiority in climbing enabling them to refuse combat by rising to a height of 5,000 meters (16,250 feet). The technical elements are identical in all aeroplanes of the same type, but their employment in combat, *i.e.*, their tactical application varies with the ability of the individual pilot in each particular case. The utilization of the tactical elements is so dependent upon their intelligent application by the pilot that it often occurs that airplanes technically inferior in all points obtain tactical advantages by reason of the courage and skill of their pilots, and even absolute victories, over adversaries better armed, faster, and more easily handled, *e.g.*, the old Farmans of 1915 over the Aviatiks of that year.

Our "Aces" in particular furnish an excellent example of good tactical handling of their machines. In general, however, it must be admitted that technical superiority is the surest method of achieving tactical superiority in the fight. Superiority of material equipment has been the chief basis of all German tactics in terrestrial combat.

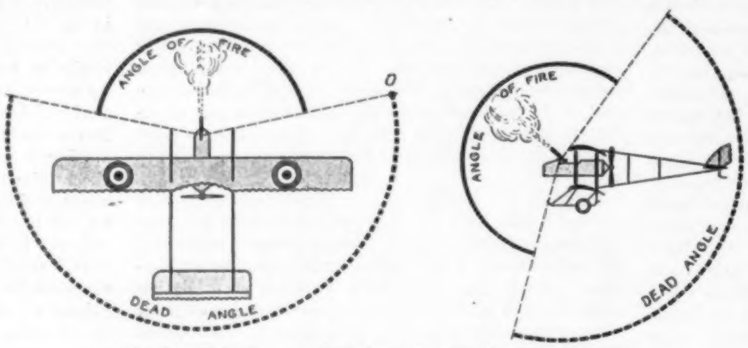


Fig. 1.—Firing area and obstructed area of a 1915 Farman

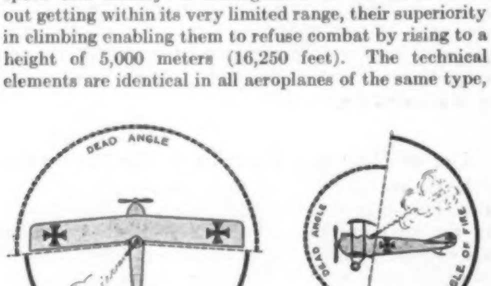


Fig. 2.—Firing area and obstructed area of a 1915 Aviatik

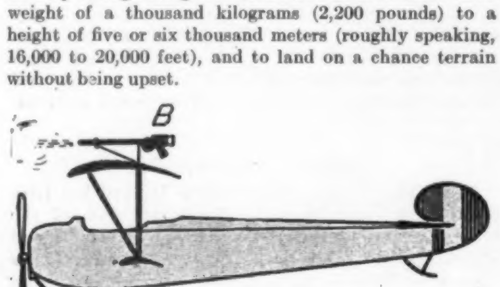


Fig. 4.—The fixed machine gun of a Nieuport

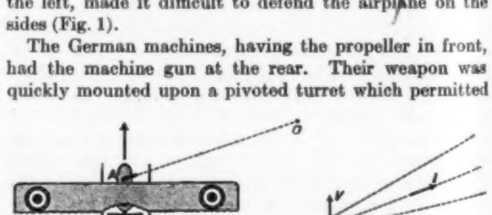


Fig. 3.—Deviation of trajectories in consequence of the displacement of the airplane

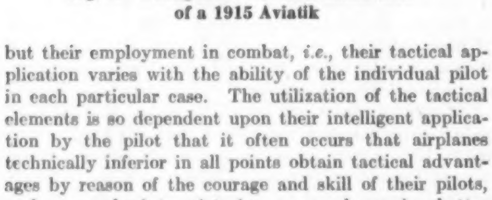


Fig. 6.—Arrangement of gun in 1915-16 Fokker

The relative importance of each of the technical factors in air fighting varies according to the work required of the machine. For a fighting airplane the order of importance is as follows: speed, ease of handling, armament, and altitude. The German pilots who have been taken prisoner declare that the superiority of the Nieuport and the Spad over the "chaser" Albatros lies chiefly in their extreme ease of handling, the other factors being practically balanced.

Airplanes for artillery, photography, petty bombardment, or protection, which by reason if their specialization of function cannot be made fast enough to avoid combat, should be constructed with a view to technical superiority in defensive armament. Handling and speed are less important elements than for fighting machines.

The big airplane intended for bombardment by night demands entirely different technical qualities, such as capacity, radius of action, facility in landing, etc.

The present speed of French and German chasing airplanes varies between 180 and 200 kilometers per hour (110 to 123 miles per hour); it might be much greater but for the fact that these machines are obliged to keep enough wing-area to enable them to raise their weight of a thousand kilograms (2,200 pounds) to a height of five or six thousand meters (roughly speaking, 16,000 to 20,000 feet), and to land on a chance terrain without being upset.

The present speed of airplane of artillery, photography, petty bombardment, and protection is from 125 to 150 kilometers per hour (cc. 75 to 90 miles), while that of airplanes for night use may easily remain as low as 90 to 120 km. per hour (cc. 50 to 65 miles), in case the exigencies of capacity demand it.

No limit is set to improvement in ease of handling, especially in machines specialized for combat. Knowledge of the formidable strains and pressures which come into play on surfaces of an extent of 25 square meters (the spread of the Albatros chaser) has arrived at such a point of precision that all sorts of aerial acrobatics are permissible, especially for chasing airplanes without any fear, normally, of ruptures or deformations.

If there are still numerous accidents due to ruptures they must be ascribed to inevitable imperfections caused by the necessity of producing large quantities of machines in a short time and of entrusting delicate bits of construction to mechanics too hastily trained.

Facility in maneuvering is a function of the judicious distribution of the strains to which the airplane is subjected; the ascensional strain, gravity, and the strains resulting from the use of the controls.

But after all the armament remains the decisive factor in the combat, for it is this which destroys the power of the enemy.

I.—At the beginning of the war, when aviation had a relatively obscure rôle, and had not assumed the importance of a factor indispensable to victory, the necessity of the "mastery of the air" had not yet made itself felt, and aerial combat was a rare event. The airplanes went out armed with a carbine or rifle, and were generally careful to refrain from attacking. Then, little by little, each desiring to keep secret his own preparations, but seeking to know those of the enemy, combats became frequent. It became necessary hastily to mount machine guns with improvised supports which had to be perfected very rapidly. This was the first period of aerial combat, which had scarcely more than a single formula of armament. The airplanes, all two-seaters, were provided with a machine gun operated by the passenger.

The majority of the French airplanes, having the propeller at the rear, had behind them a considerably obstructed area or blind spot which favored surprise attacks. The machine-gun, being generally placed on a pivot in the front of the nacelle, either to the right or to the left, made it difficult to defend the airplane on the sides (Fig. 1).

The German machines, having the propeller in front, had the machine gun at the rear. Their weapon was quickly mounted upon a pivoted turret which permitted it to be rapidly turned in order to fire to the right or the left. The obstructed area was in front and under the observation of the pilot (Fig. 2)

It was quite surprising to observe how often furious combats at a short distance had no practical results except for a few balls in the wings. In the first place the munitions were limited. Either a few belts of 25 cartridges each or a drum of 100. The functioning of the machine guns was delicate, the supports not very practical, and the precision of the fire incredibly defective. The causes of this inaccuracy were many, proceeding chiefly from errors of aim due to the relative speeds to the two combatants; but owing likewise to the very considerable vibration produced by these over-light

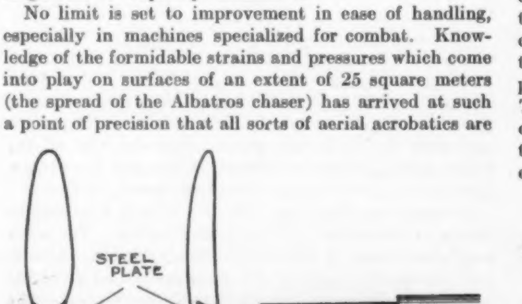


Fig. 5.—Garros type propeller for firing between the blades

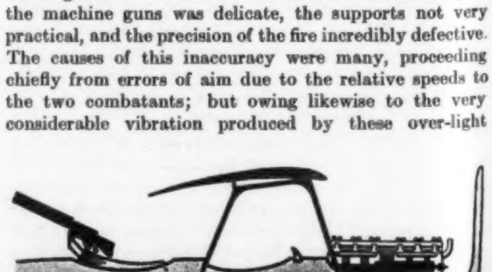


Fig. 7.—Position of gun on 1917 Albatros

*La Nature (Paris).

machine guns, which prevented all accurate aim; also to the inconvenient positions the gunner was obliged to take in order to fire in the direction O as shown in Fig. 1; and finally to the difficulties in handling a heavy arm in a wind of 100 km. per hour (60 miles per hr.).

Moreover, the trajectories of the shots fired, at the side, towards O (Fig. 3), were thrown out of line by new forces: the initial lateral speed, produced by the speed of the airplane (force V Fig. 3), the lateral wind pressure upon the projectile by this same speed (force L Fig. 3); two forces V and L which are compounded with the initial speed I of the ball and deform the trajectory.

The sight of the gun, moreover, ceases to give a pre-

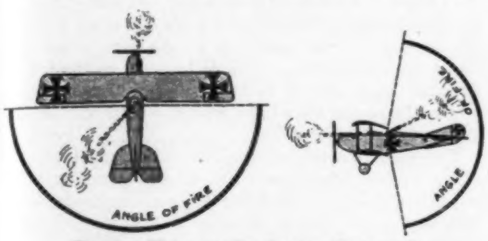


Fig. 9.—Firing angle of 1917 Albatros C

cise indication for arms which fire almost vertically, above or below, and but rarely in a horizontal plane. The distance of the shots is generally less than 400 meters (1,300 feet) and if we note this element of error it is merely to add it to the preceding causes to show the great difficulties involved in aerial firing.

II.—The second period comprises the organization of the armament on board airplanes of specialized missions. Three principal formulas have been adopted by our enemies as well as by us:

1. Firing forward by a fixed machine gun shooting above the propeller or through it (one-man machines).

2. Firing forward by fixed machine guns shooting like the preceding, but with the addition of a machine gun on a *tourelle* shooting towards the rear (two-seaters).

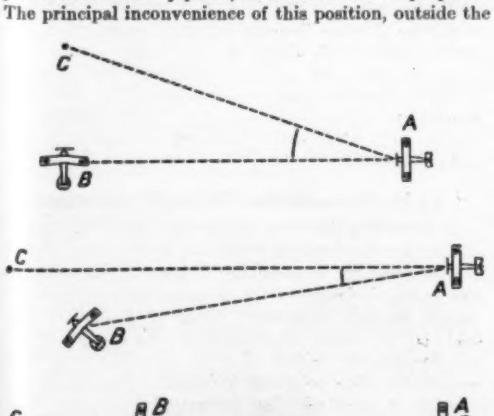
3. Firing forward by a machine gun on a *tourelle*, towards the rear by a machine gun on a *tourelle*, and under the fuselage with the gun on a pivot (three-seaters).

The constructors have been led to study the formula of fixed firing towards the front, either through the propeller or above it, in the first place to enable one man machines to become fighting machines, and next to avoid all the inconveniences indicated above in the case of movable guns on *tourelles* or pivots.

Evidently the first result of employing a fixed gun is to enable the pilot of a one-man machine to operate his own weapon. The gun fires in the axis of the airplane; the pilot aims at the object with his entire machine; the aim is accomplished by a sight strictly parallel to the gun. In the second place, since the gun is fixed and consequently forms a solid part of the whole mass of the airplane, all firing vibration is suppressed.

Other advantages result from this arrangement of the gun, the excellent position of the pilot gunner, no more deviation produced by lateral wind (force L Fig. 3) and by the initial speed of the airplane (force V); this force V is transformed into a supplement of the initial speed of the ball.

1. The first application of the fixed gun firing above the propeller dates from the appearance of the Nieuport chasing biplanes, (Fig. 4). This machine gun was placed above the top plane, and fired above the propeller. The principal inconvenience of this position, outside the



Figs. 14, 15, 16.—The direction of the fire, taking into account the relative displacement of the enemy

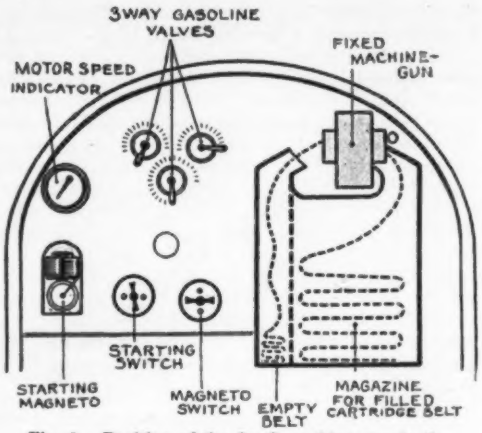


Fig. 8.—Position of the fixed machine gun in the fuselage (as seen by the pilot)

Fig. 11.—Parabellum mitrailleuse movable on a tourelle

A, lateral reel carrying a band of 250 cartridges; *B*, sack into which the shells are ejected; *C*, jointed fork; *D*, carriage revolving on the turret. Weight 12 kilograms (26. lbs.); With 250 cartridges and accessories 32 kg, (70.4 lbs.)

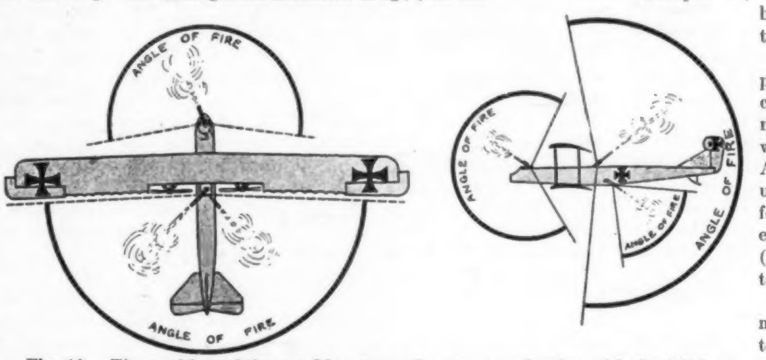


Fig. 13.—The position of the machine guns, the zones under fire with the 1916-1917 Gotha

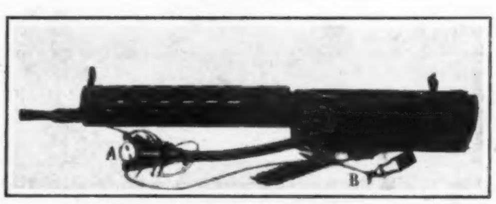


Fig. 12.—Fixed Maxim machine guns

A, arrangement for synchronizing from the motor; *B*, grip of bowden control governing the fire. Weight 13.3 kilograms (29.26 pounds). With 500 cartridges and support 36 kg. (79.2 lbs.)

great resistance to forward movement, was the difficulty of loading the arm. To reload the gun the pilot turned it upside down in B, and was then able to remove the discharged disk and replace it with a new one containing 47 cartridges. These 47 shells were quickly fired at the rate of three or four hundred per minute.

It is easy to fancy the difficulties encountered by the pilot, who not only had to drive his machine, but fire and reload his weapon. In fact, if the pilots of our first Nieuports did not obtain a decisive result with the first disk, they were obliged to stop fighting. The second application of the fixed machine gun was the shooting through the propeller, first practiced by Garros. At first thought the principle of this seems extremely curious. The gun was fired in the normal manner. To keep the balls from striking and breaking the blades of the propeller two plates of extremely hard steel were fitted onto the blades at the point where the balls passed (Fig. 5). The balls which hit these plates were deflected and lost, but the others passed between the blades and continued their course towards the objective. The percentage of balls lost was negligible, being less than seven or eight per cent.

But a latent defect soon brought about the abandonment of this arrangement; this was a loss of speed on the part of the airplane of 20 km. per hour (65,000 feet or over 12 miles). As a result of its transformation the propeller lost a part of its tractive force, a reduced efficiency resulting from the tapering at A. a reduction of the pitch of the propeller being made to compensate the resistance of the steel plates, and thus maintain the motor in its normal action (Fig. 5).

This technical superiority of armament could not compensate in a chasing airplane for the tactical inferiority proceeding from a lack of speed.

The third application of this formula was invented by the Germans at the time their Fokker chasing single-

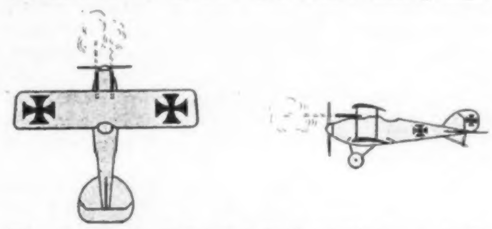


Fig. 10.—Firing of the two fixed machine guns in the forward part of 1917 chasing Albatros

seater appeared (Fig. 6). The fixed machine gun fires through the propeller, but it is governed by the motor, its action being synchronous with that of the motor. The propeller making 1,400 revolutions per minute, and having two blades, it is obvious that the barrel of the gun is crossed by the blades 2,800 times per minute, hence the regulation of the firing must be sufficiently precise to permit the balls to pass in these intervals (a 46th of a second).

The control of the machine gun by the motor is effected by suitable gearing (Fokker, Albatros, D. Halberstadt, etc.), or by flexible transmission (Albatros, C. Rumpler C). The pilot operates his weapon at will by pressing on the grip of a Bowden control.

This application of firing through the propeller by synchronization of the machine gun with the motor is the arrangement adopted on the majority of airplanes, whether belonging to the French, the Allies, or the enemy. The gun as sheltered under the hood of the motor (Fig. 7), its feeding is easy, and likewise clearing it of empty magazines. The cartridge boxes (Fig. 8) are capable of holding belts of 800 to 1,000 cartridges per weapon.

The chasing airplanes are usually one man machines, it being found preferable to omit the observer to obtain a machine which is speedier, easier handled and capable of going higher and farther.

The German series of Albatros D I, D III, Halberstadt Roland D, Ago D, Fokker D, have two fixed machine guns firing through the propeller, and each provided with 1,000 cartridges (Fig. 10).

2. Another formula of armament (Fig. 9) exists for less rapid two-man airplanes, charged with the mission of directing artillery fire, taking photographs, or making petty bombardments. This series corresponds to the Albatros, Rumpler, Aviatik, L V G., the whole series of C, two-seaters, flying only from 140 to 160 km. per hour (cc. 85 to 97 miles).

Their armament is defensive; a forward machine gun fires through the propeller, this being of special service when the defence of these machines require them to attack, and a rear machine gun is mounted on a *tourelle* We have likewise adopted the same arrangements for our airplanes of equivalent series.

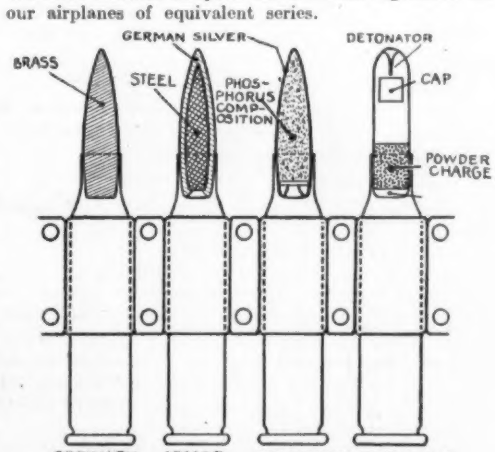


Fig. 17.—German ammunition

The forward machine gun is generally quite as powerful an arm as the weapon employed by the infantry. The rear gun on the *tourelle* is a much lighter arm. The fixed machine guns are fed by belts, the mobile guns by belts rolled on reels or by disks (Figs. 11 and 12).

3. The third formula of armament in present use is that which is applied to the three-seat airplane, whether constructed for protection or for bombardment (Fig. 13). This is an airplane whose armament is essentially defensive; to free the forward part of the fuselage the airplane is constructed with two motors or two propellers. In this category come the Gotha type G, Friedrichhafen G, A E G. G, and Rumpler G. This series of airplanes is very recent; their speed appears to be in the vicinity of 150 km. per hour (about 90 miles) a speed equivalent to that of the airplanes for direction and for photography, series C.

They seem to have been designed for protection of definite points and lines, or for protecting machines, directing artillery, or for executing heavy bombardments (London).

Their armament comprises a movable machine gun on a forward *tourelle*, a movable machine gun on a rear *tourelle*, and a movable machine gun on a pivot, the latter fired through a trap for the lower fire under the fuselage. These strongly armed airplanes are difficult to attack, since any machine approaching them is inevitably under fire from one of their guns. The best tactics to pursue against one of these fortresses of the air is, evidently, to fatigue the rear gunner, who can be forced to keep in constant motion between his *tourelle* and his lower trap if the Chasing aviator harasses him sufficiently by his acrobatics.

This type of airplane of heavy tonnage ought to be increasingly developed, as the protection of the average airplane becomes more and more difficult. and long distance bombardments is necessary either to paralyze certain industries or to make reprisals on enemy cities.

If the adoption of a fixed gun firing in the axis of the route pursued by the machine suppresses a portion of the strains which derange the firing, it still remains to overcome all these difficulties for the mobile guns, and it is necessary also to improve the accuracy of fire of the fixed guns due to the relative speed of the machines. A correction of the aim is indispensable—it is this which the hunter does when he sees a head of game in motion.

The correction to be made is considerable if the routes of the two airplanes are perpendicular to each other (Fig. 14). While the ball is traversing the course A B the airplane B will be at C; it is necessary therefore for A to aim according to the line A C, *i.e.*, with the angle B A C which measures the correction.

The correction is less in the case of Fig. 15, and nil in that of Fig. 16.

To obtain great precision of fire it is of advantage therefore to attack the enemy when as nearly as possible in the position of Fig. 15; the machine thus attacked will avoid, so far as possible, remaining in the line of fire of the attacking machine; it is thus that the pilot of the Chasing machine can make his skill tell.

The necessary correction is obtained by special sighting apparatus, being automatically deduced according to the angle under which the enemy airplane is seen by the gunner. These highly interesting "sights" must not at present be described.

The above formulas are those in use on the majority of our own and of the enemy's airplanes. But there exist certain other formulas in use on trial machine, or on some rare specimens which are destined to disappear. The great tendency is to provide identical characteristics for airplanes having the same mission. Witness the table below:

CHASERS

200 H. P. motor; monoplace biplanes having 25 square meters of suface: two machine guns firing through the propeller (Series D).

ARTILLERY, PHOTOGRAPHY, BOMBARDMENT

220 H. P. and 260 H. P., single motor two-seaters of 40 square meters; one machine gun firing through the propeller; one upon the *tourelle*. (Series C).

PROTECTION AND BOMBARDMENT

500 to 550 H. P. two-motor, three-seater of 100 square meters:

1 machine gun forward on a *tourelle*.

1 machine gun at the rear on a *tourelle*.

1 machine gun underneath on a pivot. (Series G).

The munitions employed by the Germans at present are the following: ordinary bullets, incendiary, perforating, and explosive balls (Fig. 17). The difficulties encountered by our enemies in manufacturing munitions so highly specialized force them to use ordinary bullets in the majority of cases.

The incendiary and tracing balls are hollow, and contain a combustible substance with a phosphorus base. They leave behind them a luminous trail and are designed both to set fire to balloons and gasoline tanks and to enable the gunner to rectify his fire.

The perforating balls are composed of a core of hard steel enclosed in an envelope of German silver. They are designed to pierce metal portions, especially motors. Other balls are explosive, the belts and drums, containing 10 to 15 per cent of these. They have the form and the composition of a small shell: a small plate forming an exploder over a capsule and detonating substance.

All these specialized balls have trajectories which differ perceptibly from those of ordinary balls, a difference caused by their shape and weight.

In combat taking place at a distance of less than 300 meters (975 ft.) it is not necessary to employ special sights.

The bitterness of air fighting increases daily; it is vital for us to obtain absolute mastery of the air. The airplane has shown itself too powerful a weapon for us to allow our enemies to balance us in its possession.

Self-Inflicted Injuries Among Soldiers

PROFESSOR ATTILIO ASCARELLI, of the Headquarters Military Hospital, at Rome, has published[1] some interesting observations based on his personal examination of several hundred cases during the last two years among soldiers suspected of suffering from medical or surgical ailments voluntarily inflicted or simulated. The study of the exceptional causes which lead soldiers into this special kind of crime shows them to be many and various. At the front there are met with especially forms of minor injuries sufficient to cause withdrawal from the fighting line to a base hospital, and each form of injury may assume an epidemic, almost contagious, aspect, so that one special lesion becomes perdominant in a certain section of the troops, at first by the occurrence of a few cases which are often passed unrecognized, then by the rapid multiplication of similar cases and their abrupt cessation when the similarity and abundance of examples render the fraud manifest. Cases in the interior, on the other hand, are endemic rather than epidemic, are more numerous in one place or another, assuming sometimes one form, sometimes another. The contributing factors in these cases are complex. For example, instances are of more frequent occurence in cities than in rural districts. The predominant political feeling also determines their occurrence in certain localities, while social condition seems, on the other hand, to exert but little influence. Family conditions are of some importance; sometimes it is the father of a large family, sometimes a soldier who has had a brother killed in action, sometimes penurious family surroundings, induce the resort to fraud in order to avoid military service, while at other times it may be the result of nostalgia. These injuries are relatively more frequent in young adults than in those habituated to camp life, are more numerous during the days following a new levy, and are most numerous in the recruit who is overpowered by fear of the unknown, while later on he gradually adapts himself to his new life. A feeling of impunity is of particular importance, the military culprit pays little heed to the condemnation awaiting him after the war, and sometimes does not hide the fact that he has been able by these means to obtain exemption for some months, so much so that relapses occur in the same hospitals where such cases are treated and some who have even been punished by the authorities return later on with the same or some other form of self-inflicted injury. In about one-third of the cases the existence of former wounds or diseases supplies the impulse which which determines the injury, a small wound completely healed constitutes an admirable substratum for the application of some caustic; a contusion or sprain suggests the production of more permanent swelling by means of tight bandaging; a conjunctivitis or otitis contracted in childhood affords an explanation and excuse for the same conditions wilfully induced. A further cause is to be found in the leave granted during winter or after convalescence, the soldier who returns for a longer or shorter time to his family surroundings is tempted at the expiration of his leave, and often under the advice of evil companions, to resort to questionable practices. The most frequent injuries met with by Professor Ascarelli were:

(1) Inflammation and abscess due to the injection of chemical substances such as petrol, benzine, turpentine, and chloride of lime generally into the calf, knee, or heel. Sometimes on puncturing such abscesses an odor corresponding to that of the substance injected was observed. (2) Abscess from injection of fæcal matter, the nature of which may sometimes be detected by the fæcal odor of the pus and the presence of a raised spot at the site of puncture. (3) Chemical cauterization, usually by soda or potash lye, sulphuric or hydrochloric acid, aqua regia or chloride of zinc; the diagnosis is not difficult, but a general examination is necessary to exclude any condition that might explain the occurrence of the ulcer, such as syphilis, diabetes, syringomyelia, varix, etc. (4) Burns, caused by boiling water or lye, the shape and size of which often do not tally with the cause given in explanation. (5) Hard œdema, a kind of cellulo-dermatitis produced by self-inflicted blows frequently repeated, generally on the back of the hand or foot, the anterior part of the thigh, or knee. The region appears swollen, elevated, more or less regular in outline, and cyanotic. X-ray examination is always negative. (6) Odema from stasis produced by tight bandaging. (7) Otitis caused by the introduction of irritants, generally grafted on a real chronic otitis. The presence of lesions in the meatus and concha may reveal its artificial nature, which may result in stenosis or even facial paralysis. (8) Conjunctivitis caused by castor-oil seeds and other irritants. (9) Dermatitis from plants—*i. e.*, the roots of ranunculaceæ and euphorbia. (10) Voluntary mutilation by firearms, seem almost exclusively in the war zone, in which blackening round the wound of entrance forms a guide as to the true cause.

Professor Ascarelli believes that only a small minority of the soldiers who come under medical observation for self-inflicted injuries exhibit definite criminaloid tendencies, but draws special attention to the marked hypoalgesia associated with such cases, which can be demonstrated by the absence of painful impressions, dilation of the pupils or acceleration of pulse, when the patient is subjected to the application of strong faradism.—*The Lancet.*

[1] Il Policlinico, May 23rd and June 3rd, 1917. Practical Section.

Early Civilization in America

PROF. ELLIOT SMITH has been recently developing in an extraordinarily interesting manner the thesis that the Pre-Columbian civilizations of America—or at least many important features in those civilizations—were not truly aboriginal, but came in a cultural wave from Asia across the Pacific Ocean, the original starting-point of the most remarkable characteristics being Egypt. The facts are set out fully in a paper entitled "The Influence of Ancient Egyptian Civilization in the East and in America" which will be found in the *Bulletin of the John Rylands Library* for January to March 1916. Prof. Smith believes that the extremely peculiar culture of Egypt was spread eastwards by mariners, mainly Phœnicians, for several centuries after B. C. 800. To quote the author's own words, he thinks that "the essential elements of the ancient civilizations of India [the pre-Aryan civilizations], Further India, the Malay Archipelago, Oceania, and America were brought in succession to each of these places by mariners, whose oriental migrations began as trading intercourse between the Eastern Mediterranean and India some time after 800 B. C., and that the highly complex and artificial culture which they spread abroad was derived largely from Egypt (not earlier than the 21st Dynasty) but also included many important accretions" from other sources, and that after traversing Asia and Oceania, and becoming modified on the way, the stream finally "continued for many centuries to play upon the Pacific littoral of America, where it was responsible for planting the germs of the remarkable Pre-Columbian civilization."—*Science Progress.*

Acquired Radio-Activity

SOME experiments by W. Crookes are given in the Philosophical *Transactions* of the Royal Society, 214, p. 433. When diamond, ruby, garnet, gold, platinum, yttria, calcium sulphide, zinc blended and barium platinocyanide are bombarded in a high vacuum by kathode rays in no case can any permanent activity be recognized either by photographic or electrical means. By direct exposure to radium, however, many of the above substances become colored, the color depending on the substance. Diamonds take a full sage-green tint, the depth depending on the time of exposure. In addition to change of color diamond becomes persistently radioactive, continuously giving off α-, β-, and γ-rays. The acquired color and activity withstand the action of powerful chemical agents, and continue for years with apparently undiminished activity. Removing the surface by mechanical means, however, removes both color and radio-activity.

Light Transmission Through Telescopes

ATTENTION is drawn to the importance of the amount of light lost in telescopic apparatus by reflection and absorption, and of the possibility of much of the reflection loss being obviated by the glasses being subjected to certain chemical treatment (details of which are withheld.) The process is stated to be an extension of that put forward by Taylor in 1904, in which the lenses, immediately after polishing, were immersed in an aqueous solution of ammonia and sulfuretted hydrogen. Flint glasses seem to be most affected by the process, while crown glasses are almost unaffected. The results are attributed to the formation of a vitreous surface layer of low refraction.—F. KOLLMORGEN in *Am. Ill. Soc. Trans.*

Companions of the Sun—I*

Some of the More Intimate Features of the Solar System

By Albert D. Watson

Limited to a narrow physical environment we have developed what may be termed a physical consciousness. Even the blaze of the stars, that jewels night with a serene beauty challenging word pictures in vain, deceives us with a nearness which is only apparent. The earth seems solid enough and even the heavens appear to be within reach. A child thinks that with a long ladder, he might climb up into the sky and shovel the snow down. We are all near children, and it is hard for any of us to realize with one of the oldest writers of the race that "He stretcheth out the north over the empty place and hangeth the earth upon nothing." Yet the solid earth which serves us for a foundation has itself nothing solid on which to rest, but like all the other companions of the sun, is suspended in space by cables of law. If our earth-mother did not hold us closely to her bosom we should ourselves fly out of her arms and become prodigals like many another piece of free and independent world-stuff.

We cannot see the solar system whole. Being a part of it ourselves, while we look at a second part, a third part is behind us. Those companions of the sun seen by us at any time are strewn over the wide ceiling of space and mixed with the stars. It is clear, therefore, that we can see the solar system only ideally.

Finding oceans of space on all sides of us, we are at first overawed by the sense of our utter insignificance. We seem almost lost in the universal immensity. Our thought is plunged into interminable deeps. Nevertheless, we too are composed of star-stuff, and are essential parts of the whole cosmos. Even a child may say from the vantage of the soul view:

"The open heavens are too small to contain me,
I contain them."

Let us, then, try to see the solar system as clearly as if there were nothing else in the heavens, and we looking on it from the outside. The unwearied endeavors of countless investigators, toiling through nnumerable years, despite inconceivable difficulties and discouragements, enable us to get an accurate conception of what the solar system would look like if we could see it alone and see it whole.

Imagine then, a great wheel of worlds with a hub more than six hundred times as large as the combined volume of all the orbs that encircled it. This sun-hub is brilliant, blazing, colossal. Jupiter with his nine moons or Saturn with his ten moons and his rings, is but a toy in comparison with this almost inconceivable pageant. The zodiac is the rim of this vast wheel, and we of this little earth are in the plane known as the ecliptic plane, because here all the eclipses seen by us take place.

Looking at this wheel from the outside, yet from the plane of the ecliptic, it would resemble a long line of orbs extending over 6,000 000,000 miles, with the sun blazing in the centre. The sun's diameter is about as one mile in seven thousand of the length of this line of sun-companions. This makes the sun seem comparatively small. Yet if our moon had a satellite revolving in the ecliptic plane at a distance of 190,000 miles, it would be possible for the earth to stand at the sun-centre and our moon could revolve around the earth, and the satellite of the moon could revolve around it, and all would still be far within the circumference of the sun.

If our eye were placed above the plane of the ecliptic, we should see the solar system as an ellipse somewhat after the appearance of Saturn and his rings at the present time. As our eye rose higher above the ecliptic plane, the smaller diameter of this ellipse would increase till finally it would be a near circle.

The companions of the sun comprise eight planets, twenty-seven moons, hundreds of comets, and thousands or even millions of meteors and tiny particles of world-stuff, all floating along with the great household of the sun. They may be classified as follows:

1. The major planets and their moons.
2. The minor planets.
3. The comets and meteors.

All these bodies are moving around their primaries in elliptical orbits.

Of the eight major planets, the four nearest to the sun are much smaller than the others, indeed, they are as to their size, pretty well within the class of large moons. Mercury, Venus, and Mars are quite perceptibly phased to our vision, whereas the larger, outer four owing to their comparative distance from the sun, are free from any perceptible phasing. The two innermost planets, Mercury and Venus, are without moons, being exceptional in this respect; indeed, they may themselves almost be regarded as moons, since they turn always the same face sunwards. This coincidence of rotation with the revolution periods obtains in the case of all the moons where, in the nature of the conditions, such a coincidence is determinable. (See Bulletin No. 64, Lowell Observatory.)

The solar system is the unit of group astronomy. There are probably, in other solar systems than ours, bodies with characteristics not represented in our group, but on the whole, the system in which we live is a good example of the family of a star. The unit of distance within our sun-family is the distance of our earth from the sun, which is roughly 93,000,000 miles. It is known as a *sun distance*. Out in the general star-fields the unit of distance is the space covered in one year by a light-ray, and is called a *light-year*. This amounts to over five trillions of miles, or over 60,000 sun-distances. The star nearest us, so far as we have been able to ascertain, is Alpha Centauri at four and two-fifths light-years distance from us.

Here, then, is our solar group or star family moving on in space at a rate of nearly 12 miles per second, its individual orbs all the while revolving, rotating, librating, describing polar circles in the sky, and acting like a group of gyroscopes held together by chords of infinite harmony, and marching to the music of the morning stars.

Mercury is three-eighths of a sun-distance from the solar centre, turns always the same face to the sun, and can be seen only when its line to the sun is nearly at right angles with ours. He is too bright to see in much detail. It has been stated that Copernicus never saw Mercury, but apart from its general improbability, there is evidence to the contrary.[1]

Mercury is the smallest of the major planets. (Diameter, 3,000 miles.) His orbit is inclined at an angle of seven degrees to the plane of the ecliptic, hence he passes between us and the sun only twelve times in a century whereas if it were coincident with that plane we should have a transit of Mercury at least three times a year[2]. Two pounds on the earth's surface would weigh but one in Mercury. His axis of rotation is nearly perpendicular to the plane of his orbit, which being very eccentric, produces a season dependent upon his varying distance from the sun. His greatest removal from the sun varies to his least as three to two.

Having no appreciable atmosphere, Mercury is not eligible as a health resort. His year consists of 88 of our days or less than three months. Dividing this year into summer and winter according to his less or greater distance from the sun, each of these periods of about six weeks measures a semi-revolution in his orbit. The coldest hour in winter on the sunward face of Mercury is probably hotter than the boiling point. The hottest hour on the anti-solar hemisphere must be comparatively cool and may have been the abode of intelligent beings before its atmosphere was exhausted. If there ever were such beings, they must have kept out of the sunlight. The strongest contrast of Mercury with all the other planets is in the fact that its orbital inclination to the ecliptic plane is three times as great as the average of all the other planets and more than double that of the next greatest which is Venus.

Venus is the earth's nearest neighbor in the sun-family, being two-thirds of a sun-distance from the solar centre. She is about the same size as the earth, and in all probability keeps always the same face sunward. Her year is about seven of our months, and as her axis is perpendicular to the plane of her orbit, which is nearly circular, there are no seasons in Venus. She is a warm planet, but her dense atmosphere moderates the heat. If she turns always the same face to the sun, as appears increasingly probable, this fact bears an interesting relation to the question of the habitability of this planet. The sunward hemisphere would, in that case, be too hot for habitation, and it is possible that the opposite side would be too cold. There is a borderland, which we might name the twilight circle, out of the direct sunrays yet not entirely dependent upon starlight, where it is reasonable to suppose that habitation may be quite feasible.

Owing to the inclination of her orbit of three-and-a-half degrees to the ecliptic plane, Venus transits the sun only at intervals of eight and 122 years alternately. Venus is never seen from earth at midnight, as her elongation or distance from the sun east or west never exceeds 45 degrees. She is often seen by daylight, especially in an intensely blue sky when a cloud passes over the sun. It is very important to know exactly where to look, though some have seen it when not looking for it[3]. Venus when brightest has about twelve times the brightness of the most brilliant fixed star.

We have little likelihood of ever finding evidences of life on Venus, but the Venutians, if there be any, may find our planet a most interesting and easy object of telescopy. The relations in this respect are the reverse of those with the hypothetical Martians. As the face of the earth as presented to Venus is about four times as large as that which Mars presents to us, we may be sure that the people of Venus, with means of scrutinizing the heavens similar to ours, could see far more of our life than we could reasonably hope to see of Mars'. They would have excellent maps of the physical geography of our planet, showing continents, islands, oceans, rivers, mountains, etc. As Venus is a difficult object of observation to us, so also for similar reasons, the earth would be exceedingly difficult of observation from Mars.

Unless clouds obstructed their view, the polar snow-caps of the earth would be readily visible from Venus. As the earth is sometimes 10,000,000 miles nearer to Venus than Mars ever is to us, and has four times the apparent surface presented, the only hindrance to results would be the possible conditions on the surface of Venus. Have they telescopes? Are their clouds too dense? Are there people there at all?

The phases of Venus are most interesting, especially at the period just before her inferior conjunction, when she passes between the earth and the sun. She then has the outline of a new moon, and is most beautiful, appearing as a perfect silver bow. Six pounds on earth would weight five on Venus.

The Earth is the third planet from the sun. Besides the three motions common to all planets, rotation, revolution, and progress with the sun, the earth has several other motions or librations due to lunar and near planetary attractions. The axis of the earth points at present to the vicinity of the pole star, but is describing a figure in the heavens which it completes in 25,800 years. The earth has also a magnetic period, and an auroral period, both of which appear to have definite relations with the sun-spot period of our solar centre.

Objects are lighter at the equator than at the poles. Time-recording pendulums have to be shortened for frigid latitudes. This is because the semi-diameter of the earth and also the centrifugal force are greater at the equator than at the poles.

The atmosphere of the earth helps to diffuse the light and mitigate the blackness of the shadows cast by the earth at night. It shields us from the destructive power of meteors, protects us by radiation from extreme heat and cold, and hides the stars in the day time. The blue sky would be black were it not for the atmosphere. Besides these effects, there are many beautiful and interesting phenomena due to the atmosphere. Among these may be mentioned the earth's shadow thrown up as a dim arch in the eastern sky as the sun sinks behind the western horizon. It is seen as a wide-sweeping arch gradually rising in the east awhile after the sun has disappeared. This twilight shadow is much modified by the atmosphere.

Another phenomenon dependent doubtless to a considerable extent upon the density or rarity of the atmosphere is the Aurora. While the frequency and, indeed,

*Journal of the Royal Astronomical Society of Canada.

Note—the numbers in this article, though only approximate, are reasonably accurate—A. D. W.

[1] Olmstead, in *Letters on Astronomy*, page 230, says: "Copernicus . . . lamented on his deathbed, that he had never been able to obtain a sight of Mercury," but Berry of Cambridge, in *A Short History of Astronomy*, page 96, says: "Copernicus, moreover, points out in more than one place that the high latitude of Frauenburg and the thickness of the air were so detrimental to good observation that, though he had occasionally been able to see the planet Mercury, he had never been able to observe it properly." For a fuller discussion see this Journal, vol. 9, page 264, 1915.

[2] The next transit of Mercury occurs May 7th, 1924.

[3] In a letter from a friend, dated Muskoka, August 20th, 1909, at 12.18 p. m., the following observation is reported: "About four minutes ago, I was watching a tiny cloud-craft sailing high in the east, far from any other clouds. I watched it till it was absorbed in the blue. Then, my eyes, dropping a little lower, beheld—Venus, yes, Venus, and the sun shining! I think there must have been a slight veil over the sun, for I looked away from Venus for about a minute, and when I looked back, I could not see her. The sky had become an intenser blue, and the sunshine seemed brighter. There are now some clouds floating in that part of the sky. I shall try to see her again before I go in to lunch. 12.41—Had quite a time finding her again. Watched her till a huge cloud that had partly obscured the sun covered her." A. A. E.

the final cause of auroræ are probably to be found in the sun and those disturbances of solar energy related to the sun-spots, there seems to be a state of the atmosphere which is peculiarly suited to their display.

The Moon is the fifth in size among the satellites of our solar system. Three of Jupiter's and one of Saturn's are larger, but ours is the largest of all in proportion to the mass of its primary. It follows the law governing the moons by turning always the same face towards the earth, but owing to a swinging motion, we see in all about four-seventh of its surface. On the moon there is no atmosphere to support life, no water and no weather. There is no sudden change of temperature in the constant sunlight. That portion of the sphere that receives no sunlight is partially illuminated (except at full moon) by earthshine. The remainder is so black that to go into the moon's night where it is not earth-illuminated is to disappear.

As the orbit of the moon is inclined to that of the earth at an angle of five degrees, lunar eclipses which otherwise would occur once in every lunar month, are somewhat infrequent, occurring never more than three times a year. This is obviously when the sun, the moon, and the earth are all in the ecliptic plane, the moon being therefore at one of the nodes where it crosses the ecliptic. Solar eclipses also occur only when the moon is crossing the ecliptic, therefore at new moon as distinguished from lunar eclipses which occur always at full moon. Solar eclipses never occur less than twice nor more than five times a year.

The mountains of the moon are much higher than our terrestrial peaks in proportion to the size of the orb. Accurate measurements are impossible because of the absence on the moon of a sea level from which to measure the heights of the mountains. All that can be done is to measure from the surrounding plane. The highest peak heretofore measured runs up 24,000 feet.

The moon does not perceptibly affect the earth's weather, except to glorify it with a soft, silver light. Our moon is the most beautiful of all telescopic objects, and has been the comrade and conniver with poets and lovers in all ages.

There is accumulating evidence that some of the lunar craters are not yet dead, but there is no animal life and no vegetation on the moon's surface. Six pounds on the earth would weight only about one on the moon.

Mars. Mars is the most easily observable of all the planets from the viewpoint of the earth. We can see the snow-line advance and recede at the Martian poles as winter or summer prevails. His orbit is inclined to the ecliptic plane at an angle of 1° 51′. His axis leans to his orbital plane between 23° and 24°, this being almost the same as that of the earth. His axial inclination and his orbital eccentricity, which is greater than other major planets excepting Mercury, accentuate his seasonal changes. The atmosphere of Mars is less dense than ours. Five pounds on the earth weigh only two on Mars. Water freezes at higher temperatures. The melting of the snow-caps in a planet where the mean temperature is only minus 36° Centigrade has suggested to some that these snow-caps consist of frozen carbonic acid, but the thinness of the atmosphere admits of rapid seasonal changes of temperature, and it is probable that a comfortable summer with rather cool nights prevails in the Martian tropics.

Mars as seen from the earth varies from one to about seven diameters, therefore, from one to about 49 in area. It is clear then that the most successful observations must be made when the terrestrial aphelion coincides as to date with the Martian perihelion. The opposition of Feb. 9th, 1916, was not a favorable one, since the distance of Mars from the earth was over 62,000,000 miles.

Throughout a long winter of many months, no sunlight falls on one pole, but on the opposite one a midnight sun prevails for a corresponding period. When the planet has reached the opposite segment of his orbit the relation of the poles to the sun has been reversed as is the case in our earth.

Mars has received attention out of all proportion to any astronomical interest attached to the second smallest of the planets. His human interest accounts for this. Is he peopled? If so, do his inhabitants know anything about us? The earth is nearly four times as large, viewed from Mars, as Mars appears to us. But this is offset by the fact that when we are nearest to them, in order to look at the earth they have to look against the sunlight and see only the least crescent of the earth's surface, since its illuminated hemisphere is sunward and the Martians are on the shaded side of the earth and cannot see it at all. They are in relation to us much as we are in relation to our sister planet, Venus.

As to whether there are inhabitants in Mars, we know that though the mean annual temperature is very low, the sudden changes in temperature would be well understood and could be predicted to an hour with approximate accuracy. The inhabitants could practise a systematic mobility. Migration with the seasons would be as common and as natural in Mars as to lay in coal is to us. If there are inhabitants, they probably adapt themselves by social organization, migration and irrigation to the suddenly changing temperature, water supply, and climate.

It is always summer somewhere on Mars, and summer is probably a pleasant season with cool nights. The air is clear, the skies light-blue, the weather dry. The whole climate is airy and light. To those who desire a startling glimpse of the ingenuity of an alert mind in astronomical fields, and who are specially interested in the processes of such investigations, no more interesting works could be recommended than those of Prof. Lowell, of Flagstaff, Arizona. His books dealing with Mars are unique in that field. One would like to believe the theory of Prof. Lowell, and people this companion world, our nearest brother, no less than our nearest sister Venus, with happy souls who live and love, feel a subtle communion with us and are glad.

The moons of Mars are of great interest. Two have been discovered, Deimos and Phobos. Deimos is probably about 25 or 30 miles in diameter and four Martian diameters from its primary. It revolves around Mars from west to east in 30 hours, but the revolution of the planet in the same direction in 25 hours gives Deimos the appearance of traveling slowly from east to west. Thus if Deimos were a new moon soon after sunset, the next evening at sunset he would still be about five hours up the western sky and would show a considerably developed crescent. He passes through all his phases at each appearance, remaining above the horizon about two days and a half, then disappears for a similar period. He is never seen more than 69° from the Martian equator because of his nearness to the planet. He is frequently eclipsed and often transits the sun.

Phobos is probably only about five miles in diameter, and revolves at less than one Martian diameter from the surface of the planet. It completes one revolution in about seven hours, and meets Deimos in the sky (as seen from Mars) at each revolution. It rises two or three times during each night, and almost every night is eclipsed once or twice in Mars' shadow. He is not seen from Mars beyond 35° of latitude north or south. He passes through all his phases each time he crosses the sky. Phobos frequently eclipses Deimos and both moons often transit or partially eclipse the sun. Deimos would darken about one-tenth of the sun's disk, Phobos only about one twenty-fifth. Mars must hold the record for eclipses. About 1,400 eclipses per annum are possible to the credit of Phobos and several hundred more to that of Deimos.

[TO BE CONTINUED]

Triboluminescence

ALTHOUGH the phenomena of triboluminescence have been known for a century, their explanation has made very little progress. When a piece of sugar is crushed in the dark a certain luminosity is observed. Quartz crystals and crystals of uranium nitrate show this triboluminescence still more strongly. The first account of observations of this peculiarity is generally ascribed to Dessaignes. Looking up the literature on the subject, Dr. A. Imhof, of Zurich University, finds, however, a still older treatise, of 1820, on the "Phosphorescence of Bodies," by P. Heinrich. Quite a number of new researches have been published in this century; J. Burke first observed that the triboluminescent spectrum is continuous. As different investigators are by no means in agreement, however, Imhof confines himself in his recent paper (*Physikalische Zeitschrift*, February 15, 1917, pages 78 to 91) to a tabulation of his own observations, without discussing at length the various suggestions made that triboluminescent substances should preferably be electric insulators, symmetrical and optically active compounds, that isomers should behave similarly in this respect, etc. He examines a large number of inorganic and organic substances, salts and minerals, crystallized and amorphous, glass, etc., studying in particular so far the minimum size of crystal, the color of the luminosity and the influence of temperature. In his experiments he rubs the substance in a small glass bottle (with wide neck) with the aid of a blunt-pointed rod of ivory or glass. He finds that the minimum size of particle which will reveal triboluminescence is 0.001 mm. for zinc sulphide (calcined, not free from manganese), 0.02 mm. for willemite, 0.06 mm. for quartz and uranium nitrate, 0.14 mm. for sugar, 0.7 mm. for white flourspar, etc. Very fine powders no longer show triboluminescence. Sometimes the triboluminescenec increases when the substance is heated (quartz still shows it at faint glow); as a rule it becomes more distinct when the substance is cooled (down to —80 deg. C.). At low temperatures the color changes towards the violet, if originally yellowish or greenish-blue. Imhof found that when heat destroyed the triboluminescence, cooling or radio-active radiations restored it. Elementary substances did not display the phenomenon; sulphur was doubtful, diamond was not tried, we notice. Most double alkali sulphates were triboluminescent, the chrome-alums excepted. Sodium carbonate crystallizing with 10 molecules of water was so, the same salt with one molecule of water, or amorphous without water, was not. Chemically related substances generally behave similarly in this respect; but there are exceptions. The light was mostly bluish, sometimes yellow or orange, very rarely white or red. Phosphorescent substances retained their quality when the phsophorescence vanished on heating. One fact is rather striking in Imhof's account. There is no allusion to the popular belief that the luminescence produced by crushing is due to electrification by friction. If that be so, hardness, brittleness and dryness of the substence might be of more influence than chemical composition, and one understands why the hydrated salt should differ from the anhydrous salt. Perhaps Imhof will deal with this feature in a second paper.—*Engineering.*

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